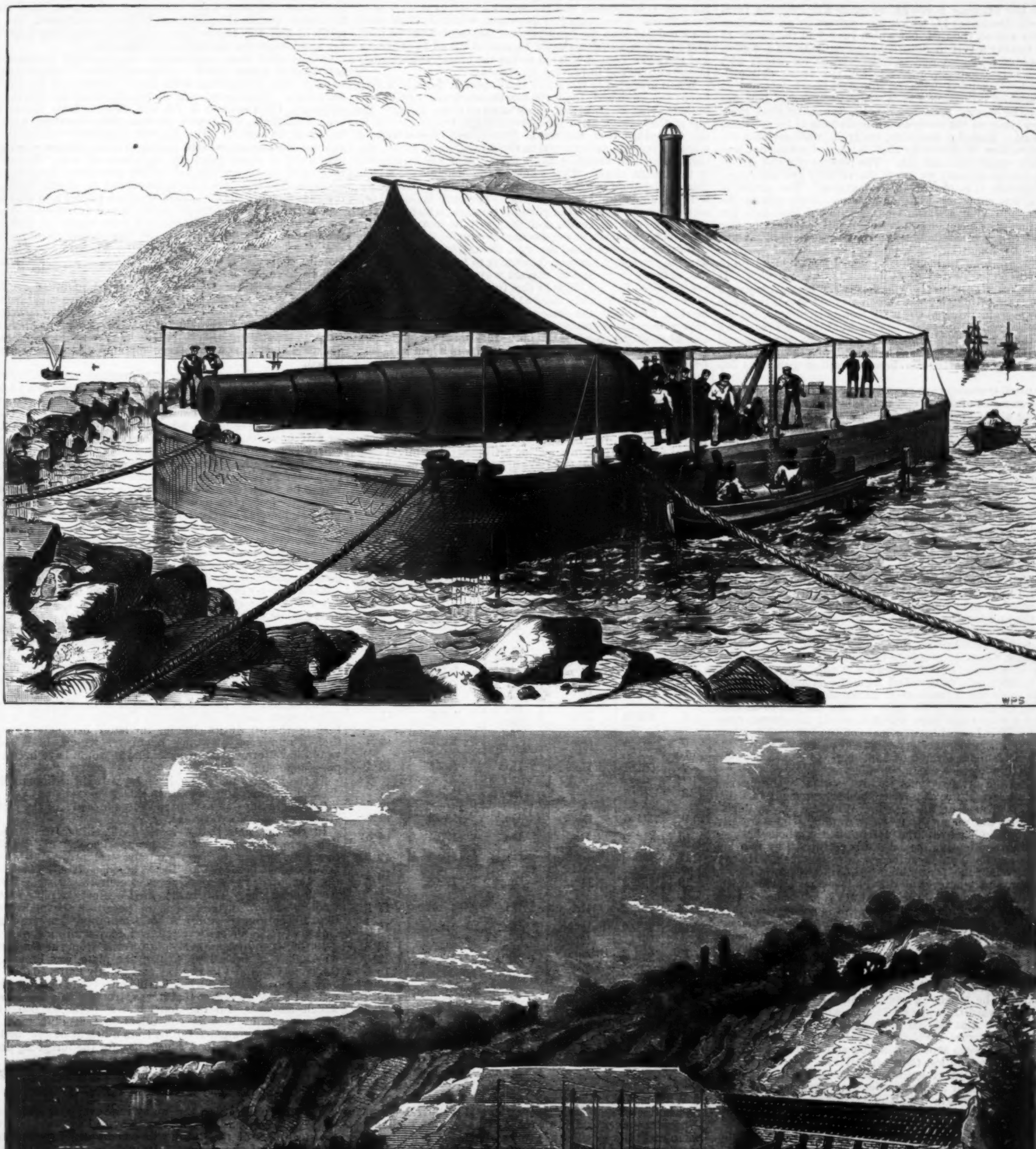
SCIENTIFIC AMERICAN SUPPLEMENT No 374

Scientific American Supplement, Vol. XV., No. 374. Scientific American, established 1845.

NEW YORK, MARCH 3, 1883.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.



TRIALS OF THE ITALIAN 100-TON BREECH-LOADING GUN AT SPEZIA, ITALY. (See next page.)

TRIALS OF THE ONE HUNDRED TON BREECH LOADER.

In our number of December 1 last we gave the highest result obtained with the new 100-ton breech loading gun on its first trials at Spezia. We then mentioned that it had discharged its projectile, weighing 2,000 lb., with a velocity of about 1,884 ft., giving 46,640 foot-tons energy, or exactly double the quantity of stored-up work obtained with our 43-ton gun. We now give a drawing of the gun and carriage, showing the loading arrangements, which have worked admirably. We look upon this as a question of special interest. The medium guns, owing to their small bore and high velocity, have great power of perforation, and produced great results against iron armor; but the advantage of a small bore must be lost when hard armor comes in which cannot be perforated, but which can only be destroyed by shattering. Against such armor large guns with a large amount of stored up work must tell most. The working of such guns, therefore, is one of the principal mechanical questions of the day.

With the drawing herewith we quote a description from the *Times*, December 11, which was written by an excellent authority and on the spot, but which cannot in the nature of things convey a very definite impression without a figure. The table of velocities and pressure speaks for itself; 16·5 tons is a very moderate pressure for the result obtained. This, indeed, coupled with the stored-up work, supplies us with the chief information as to results. It is said that the gun may be shortly fired against the Schneider steel plate that was lying on the shore awaiting its turn to be mounted and tested. Nothing, however, really depends on this, for the destruction of shields by shot is a test for the shot and the armor rather than the gun. The powers of a gun are, of course, known directly we know the velocity and weight of the projectile it is capable of discharging. The strain to which it was subjected in accomplishing this is told by the pressure, and what afterward happens to the shot does not affect the question more than the result obtained by any similar projectile, and belongs to another branch of investigation. As a matter of fact, this gun is capable of destroying 18 in. of armor with such ease that it would only tend to mislead as to its powers to connect the two together. It might be interesting to try whether a very heavy projectile fired at a proportionately low velocity would wreck the plate on a large scale owing to the work being distributed, but we have not heard of anything of this kind, and, as far as we know, the firing at the Schneider plate is a test of plates and projectiles only. The description of the mounting and working of the 100-ton breech loading gun is as follows:

The usual trunnions are entirely absent. The gun lies embedded on a sort of sledge carriage, which is a mass of steel, weighing about 14 tons. Projecting rings, A A A, which form part of the gun, rest in grooves, and prevent any backward or forward motion of the piece on the carriage, and rotary motion is prevented by strong steel straps. Thus the gun and carriage are securely bound together, having their axles parallel, and recoil together in the same direction. The carriage rests and slides upon the planed surface of two cast steel beams or side levers, B B, of about ten tons weight each. They are held together by the recoil press, and their front ends pivot vertically on a massive hinge, C. Thus the axis of the gun, the carriage, the recoil press, and the slide are all parallel, whatever the elevation, and the difficulty of restraining the rotary motion caused in other systems by recoil is completely got rid of. The whole weight is taken by two powerful hydraulic presses, D, which work always together, being acted upon by one common supply pipe. If the muzzle of the gun is to be elevated the hydraulic rams sink, and the slide, pivoting on its front end, is lowered in rear, carrying with it recoil press, gun, and carriage. The reverse takes place when the gun is to be depressed. By this simple arrangement a host of difficulties are at once eliminated, and some terrible strains removed from the system. And not only is there the advantage of harmonious recoil, but the pivoting on the end of the slide enables the gun to be fired through a very small port, which it would fill almost completely. This is an improvement on the Inflexible, where it has been found necessary to attach to the muzzle of the gun a steel shield, formed of 2 in. bars, to guard the port from the fire of rifles and machine guns.

The loading arrangements are also extremely simple, and present some features of novelty besides the mere fact that the gun is loaded at the breech. With the exception of bringing up the ammunition and ramming, which are performed by another hydraulic apparatus, the whole business of opening and closing the breech is performed by two levers close together, which are worked by one man. He cannot make a mistake, for nothing can be moved out of its proper order, and whatever position a lever may be in at the end of its last movement, the next act is performed merely by pushing or pulling the lever to the opposite side. One pair of levers works the whole breech closing apparatus, prepares the gun for loading, or opens the breech after discharge. Another pair of levers runs the gun out and in, and elevates or depresses it. It is impossible to run it back or forward too far, and the whole mighty mass of metal may be managed by the hand of a lady, who cannot possibly make a mistake. If she touches a lever, it must be to pull it back or thrust it forward from the position in which it then lies, and no movement that can be made will set anything wrong. All the movements involved in opening the breech, withdrawing the breech screw, replacing and closing the breech, can be performed in less than one minute. No damage can be done in the heat of action, and the gun cannot be fired till the operation of loading and closing the breech has been completely performed. The whole process seems like magic, so simple is it, so easy, and so certain. The most inexperienced person can learn the movements in five minutes.

The hydraulic pumps are worked by a small steam engine, E, which is governed in its rate of work by the pressure of water produced. It never ceases work, but when no movement is required of any of the parts its action is feeble, and only keeps up a certain normal pressure. But if any motion of the system is required, and the touch of a lever opens the way for water to create that motion, the engine instantly sets off briskly and continues to act till the cessation of movement tells it that its services are no longer required. It then drops back at once to its slow and feeble action. The engine is seated on a tank, F, from which the pumps draw their water, and to which the water is returned after being exhausted from the various cylinders and pipes. Behind and across the breech of the gun, but entirely separate from it, is a slide bed similar to that of a lathe, and on this bed moves a saddle which carries the loading tube and a rest for the breech screw when drawn out of the gun. Now let us suppose that the gun has been fired and requires to be loaded. By touching the levers for elevating and running back, the gun is brought into the loading position exactly. It cannot go too far in either direction. A touch on another lever brings the saddle into its proper position, unlocking and turning the breech screw as it comes. A touch on the third lever brings up a piston from the rear and makes it engage a catch in the breech screw. The same lever moved in the opposite direction draws out the breech screw upon a bed made to receive it on the saddle, G, which is then drawn out of the way by a reverse movement of the lever which brought it up. As the saddle moves sideways, that part of it containing the loading tube comes into position exactly behind the rear end of the bore. The small piston which withdrew the breech screw now pushes the loading tube into the gun, the object of the tube being to protect the threads of the female breech screw from abrasion by the shot. All is now ready for loading, which is performed as in the muzzle loading 100-ton gun. The projectile and its two half charges are always kept ready on trolleys, which rise by hydraulic pressure from their places in the magazines, and arrive between the hydraulic rammer head and the breech of the gun. Other levers thrust them forward into their places; the loading tube is withdrawn and the breech closed by a reversal of the different movements just described, which do their work more quickly than the description of their action can be read. The breech of the gun cannot be moved till all is complete, and the piece cannot be fired unless the breech is accurately closed and locked to prevent its opening.

When mounted in the Italia and Lepanto, for which they have been designed, these 100-ton breech loaders will be *en barbette*—that is, they will be elevated so as to fire over the top of the battery, as in the French ships, but there will be this advantage, that, whereas in French men-of-war the men working the gun are exposed to the fire of small arms, machine guns, and shrapnel, not a single man will be exposed in the Italian ships. The whole of the machinery, which, though elaborate to describe, is simple and massive in reality, will be under an armored deck. The only break in protection by the deck is the portion through which the rear part of the gun descends, and that will be covered by the mass of metal above it composing the gun.

Having now described the gun, the method of mounting, and the process of loading, it remains to tell what the piece has actually done, and to explain why such huge weapons are required for the ships of the future. The table below shows the rounds lately fired at Spezia, but it should be remarked, first, that the strength of the gun is calculated to bear with safety a pressure of 29 tons per square inch, while the highest yet reached is only 16·5 tons; secondly, that though the greatest charges ever yet fired in a gun have now been much exceeded, the powder chamber has room for a much larger charge than any used at Spezia; and lastly, that there is an evident intention on the part of the Italians to try even more powder, experimentally at any rate. Indeed, it is not improbable that they may, as they did with the muzzle loading 100-ton gun, increase the charge till it passes the limits of safety, for the sake of experiment. Such a course would be interesting to scientific artillerists, but might damage the confidence of the Italian navy in its guns, and the Italian people in their navy. It is also probable that the breech loader will be fired at the Schneider steel plate, which is still untouched.

No. of round.	Powder charge.		Projectile weight.	Velocity—feet per second.	Pressure in bore of gun, foot tons per square inch.
	Weight.	Description.			
1	496	Fossano	—	1,433	10·9
2	551·2	Do.	—	1,496	·11
3	551·2	Do.	Chilled 1,974	1,512	11
4	606·3	Do.	Do. 1,942	1,593	11·35
5	606·3	Do.	Do. 2,001	1,609	11
6	661·4	Do.	Do. 2,005	1,676	12·5
7	661·4	Do.	Do.	1,686	12·4
8	716·5	Do.	Do.	1,767	13·6 / 14·1
9	771·6	Do.	Do.	1,833	16·5
10	716·5	Do.	Do.	1,761	14·5
11	496	Prismatic	Do.	1,423	9·3
12	551·2	Do.	Do.	1,506	10·4 / 10·3
13	551·2	Do.	Do.	Not taken	11·6
14	771·6	Fossano.	Do.	1,831	16·4
15	606·3	Prismatic	Do.	1,607	12·8 / 12·5
16	606·3	Do.	Do.	Not taken.	13·5 / 13·6
17	716·5	Fossano.	Do.	Do.	13·8 / 13·7
18	771·6	Do.	Do.	Do.	15.9 / 16

With regard to the preceding table, it is to be remarked that both Fossano—Italian—powder and prismatic—German—powder were provided for the experiment, but, finding that there was little to choose between them, the committee decided to adhere to their own explosive. Rounds 13, 16, and 18 were fired with almost the full elevation possible, namely, 11 deg. 50 min., and therefore did not register their velocity because they passed over the screens instead of through them. The range out to sea was evidently enormous, but formed no part of the test trial, and was therefore not measured. The shot was 18·4 sec. in the air before touching the water. Round 17 was fired with almost full depression, namely, 3 deg. 50 min., and plunged into the sea below the screens, throwing up a magnificent column of water about 100 ft high.

The results of these experiments have shown that guns weighing 100 tons can be manipulated with greater ease by means of hydraulic power than the 12-ton 9 in. gun without it. The whole apparatus takes up very little room, and is perfectly simple in its character. There is no reason why a gun of 150 or 200 tons should not be manipulated with equal ease.—*The Engineer*.

RECENT ARTILLERY EXPERIMENTS AT SPEZIA.

The magnificent Gulf of Spezia, which Napoleon I. selected as the principal port of war of his empire on the Mediterranean, has, in our day, seen arise on its shores the most important military establishment of the kingdom of Italy. Spezia, rather than Gâvre in France and Shoeburyness in England, is the field on which the gigantic contest between guns and armor-plate is being carried on. In fact, there have recently been tested here not only those leviathans of modern artillery, Rosset's and Armstrong's 100-ton guns, but also some of the thickest armor-plate known. The experiments with the armor-plate were made in a small cove on the southern side of the gulf, at the Muggiano battery. It is here that the memorable experiments of 1876 occurred—those experiments that marked the beginning of a new era in the history of armor-plate, whose origin is French and dates back, as well known, to the time of the Crimean war. In the experiments of 1876 the superiority of the armor-plates of homogeneous metal presented by Messrs. Schneider & Co. was so manifest that those of iron were thenceforward doomed to disappear, and the Sandwich system (English) was entirely abandoned. As a result of this the Italian navy decided to adopt the Schneider armor-plate for the Duilio and Dandolo.

Shortly after these experiments English skill produced a new kind of armor called "compound plates," which began to enter into competition with those produced at the Creusot works. These compound plates, which are the invention of Messrs. Ch. Cammell & Co. and Messrs. John Brown & Co., of Sheffield, are formed of iron plates provided with a facing of cast steel. The English admiralty, thinking to gain an ascendency over the navies of other nations, adopted this style of armor-plate for its vessels of war. But Mr. Schneider, by improving and further perfecting the product of his works, had meanwhile succeeded in greatly increasing the efficiency of the plates that had gained him his success in 1876. These new plates of his had at different times been put to the test at Gâvre, and were finally adopted by the French navy for armoring its largest and most recent war vessels, such as the Terrible, the Furieux, the Amiral Baudin, and the Formidable. The navies of some other nations have also adopted them.

Not long ago the Italian navy, having to order armor-plate for some of its new vessels, decided to make some comparative experiments with the two competing systems, and accordingly at the end of last November these tests were undertaken at the Muggiano battery with one Schneider plate and with two of the compound plates above mentioned.

The Messrs. Schneider again triumphed most brilliantly over their rivals, and the results obtained with their plates are the most remarkable that have ever been reached up to the present time. The conditions of the test were formidable; for the three plates, which were 3·3 meters in length, by 2·62 in width, and 48 centimeters in thickness, were required to be submitted to the firing of a 100-ton Armstrong gun of 45 centimeters caliber, throwing a 908 kilogramme projectile of chilled iron. The first shot fired at each plate was to be projected with sufficient power to perforate a 48-centimeter iron plate (corresponding velocity of the projectile 374 meters, charge 149 kilogrammes of Fossano progressive powder). The firing was to be continued with the power necessary to perforate a 60-centimeter iron plate, that is, one presenting a thickness greater by a quarter than that of the ones experimented upon (velocity of projectile 474 meters, charge of powder 217 kilogrammes).

Each target was fixed against a strongly braced piece of woodwork 1·2 meters thick. After the first shot had been fired against each of the English plates, the latter presented numerous cracks traversing them in different places, while, at the same time, the woodwork was considerably shattered.

The Schneider plate, on the contrary, into which the projectile had penetrated but 19 centimeters, was absolutely without any cracks, and the woodwork behind it was perfectly intact in all its parts.

The second shot proved a disaster for the English plates, as they were broken into five or six pieces, which fell to the base of the woodwork, leaving the latter bare and showing therein numerous yawning openings, which, in a ship, would have formed large leaks that it would have been impossible to stop.

As the English plates no longer existed, the Commission decided the comparative experiments at an end.

Our engravings on next page show the state of the plates after the two series of firings.

In the six shots that were fired, the chilled iron projectiles were all broken by the shock. The Commission was therefore anxious to ascertain how steel projectiles would behave when fired against the Schneider plate. The selection made for the first test was a compressed steel Whitworth projectile. This, when fired against the plate with a velocity of 472 meters, failed to penetrate the plate more than 20 centimeters, and was so compressed that its former length of 1·158 meters was reduced to 750 millimeters.

In the second experiment, a projectile from the Gregorini works, having been fired against the plate, was broken by the impact and had its conical part greatly flattened.

It may be imagined what terrific effects the Creusot plate resisted when we reflect that it was struck with a live power which amounts, for the four blows, to 38,000,000 kilogrammes, and which is equivalent to that of a mass of 38,000,000 kilogrammes falling from a height of one meter.

We are indebted to *L'Illustration* for the foregoing data, and for engravings.

THE STEEL PLANT OF THE FUTURE.

When we consider the many improvements which are now proposed and tested, we may safely assume that the steel plant of the future will be very different from the steel plants of the present. Its practice will probably be as follows: The ores, limestone, and fuel will be placed in the blast furnace, and the resulting molten metal will run direct into a basic Bessemer converter and therein blown until the silicon, carbon, and phosphorus are eliminated, the converter turned down, the metal deoxygenized, recarbonized, and cast into ingots; the ingots immediately taken from the moulds and put into an equalizing regenerator and therefrom delivered to the blooming mill, and rolled into a bloom, the ends sheared, and the bloom rolled direct into a rail, the rail sawed into lengths, curved and pushed through the flue of a steam boiler, the rails passing out of the boiler at a temperature of 350° F.

The slag flowing from the blast furnace will be run into slag cars. The cars are then placed in the flue of a steam boiler. The flue of this boiler will be of such dimensions as to allow the slag cars to pass in and through it. When a hot slag car is run into the boiler the flue doors will be closed,

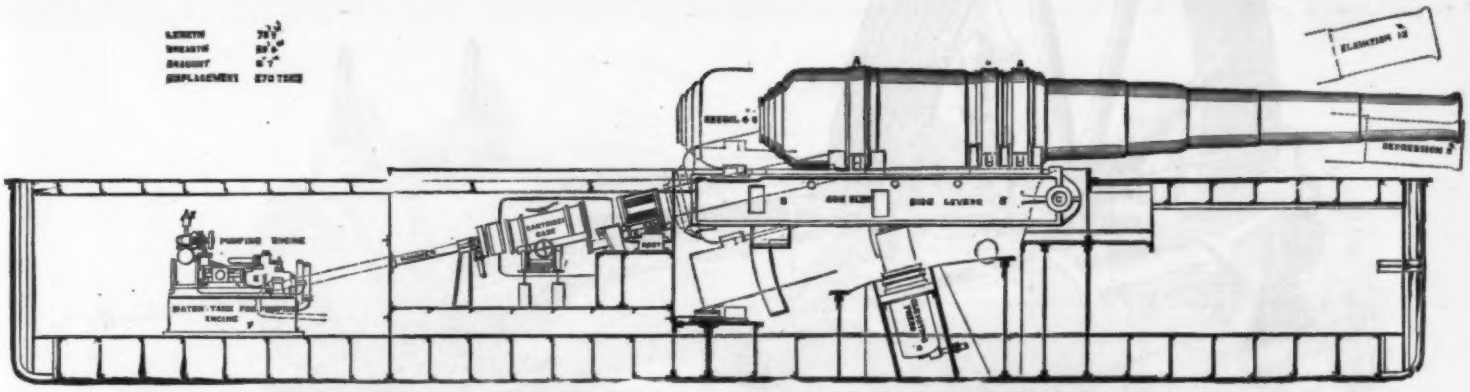
and the heat of the cooling slag will generate steam. When the slag is cooled, a hot slag car will be pushed in and the cooled car pushed out, and the slag emptied on the slag dump. The slag from the converter contains a large amount of protoxide of manganese and iron, which has hitherto been wasted because it was too high in silica to use in the blast furnace; by the new process the converter slag will be calcareous (basic) and will be used in the blast furnace as a basic flux instead of limestone, and thus all the manganese, iron, and phosphorus contained in the slag will be transferred to the metal, so that the manganese and iron will be saved and the phosphorus put into the metal to be used as a calorific element to develop heat in the converter in the absence of silicon. The waste heat of the converter will be used in drying ladles, bottoms, and converter linings, and for raising steam or heating the blast, as may be desired.

The rail steam boiler will be a flat structure with a flue five inches high, 31 feet wide, and of the entire length of the boiler. The rails when sawed and curved will be pushed into the flue of the boiler by machinery, one rail bead against the flange of the preceding rail, until the flue of the boiler is filled. After the flue is full, when a hot rail is pushed in, a cooled rail will be pushed out at the far end, and thus the operation will be continuous, the rails going in at a temperature of 1,000° F., and emerging from the boilers at about 350° F., thereby utilizing about 750 units of heat from every pound of cooling rails, which at a very low estimate in a plant making 500 tons of rails per day will generate sufficient steam to produce 1,000 horse power per day by the present wasteful method of utilizing steam.

From a plant of such capacity 600 tons of blast furnace slag will be produced, and this at an initial temperature of 3,000° F., going into the slag boilers, and an average temperature of 300° in going out, will generate sufficient steam to produce 4,000 horse-power, and from these two sources, *i. e.*, utilizing the waste heat of the cooling slag and rails, we shall have sufficient steam to propel engines of 5,000 horse-power 24 hours each day. The new plant will, therefore, have no heating furnaces, no gas-producers, no coal-consuming steam boilers, no cupolas, no ash piles, and no fuel will be consumed except that employed in the blast furnaces. This great economy in the production of steel will not be confined to nails, but may also be applied to the production of nail plate, wire rods, and other shapes direct from the ore without the use of any other fuel except that employed in the blast furnace.

What a wonderful economy in room, fuel, waste of metal, labor, brick, clay, and repairs will be secured in the new plant and its practice, and how different it will appear, as it will produce no smoke, no vivid flames from heating furnace stacks. There will be no wheeling of coal or ashes to or from the works. The metal will be moved and manipulated exclusively by air, steam, and hydraulic power. Muscle will go down, and brains be in greater demand.

To secure these great ends, where intellect economizes physical labor and the fuel which the Almighty has stored in such abundance in the eternal hills, we need a change in our educational system. There should be less time spent on the dead languages and more on physical science, which teaches us the laws which govern the organization of matter and produce every chemical and physical phenomenon observed in the universe. We should, without forgetting the things that are behind, push onward for a further and more glorious development of science and art, as there surely are much greater developments to be made in the future than the brightest men of the past ever conceived of.—*Trade Review.*



THE ITALIAN HUNDRED TON ARMSTRONG BREECH-LOADING GUN.

SULZER'S COMPOUND HORIZONTAL ENGINE.

MESSRS. SULZER BROS.' balanced-valved steam engine is well known to our readers through the articles that we have at different times devoted to it. It has received numerous applications in various industries, for on the 31st of December last there were 675 in use, corresponding to a power of 45,790 horses.

These engines are built for high powers, like compound engines, with two high pressure and low pressure cylinders. It is this arrangement that we represent in the cut on next page, along with a transmission of power by means of cables.

The compound type is, in all its details, identical with the Sulzer single-cylinder engine. It consists of two conjugate motors whose cranks are keyed at right angles upon the main shaft. Each of the frames is hollow and cast in a piece with the guide and principal pillow-block. The slides are cylindrical and fitted exactly in the axis of the cylinders. These latter, as well as their covers, are provided with steam jackets protected by coverings of non-radiating materials inclosed within polished canvas to prevent any loss of heat. The jacket of the small cylinder is alone heated directly by the steam, which afterward acts upon the piston, while the intermediate reservoir and the jacket of the large cylinder are put in communication with the steam piping by branches simply.

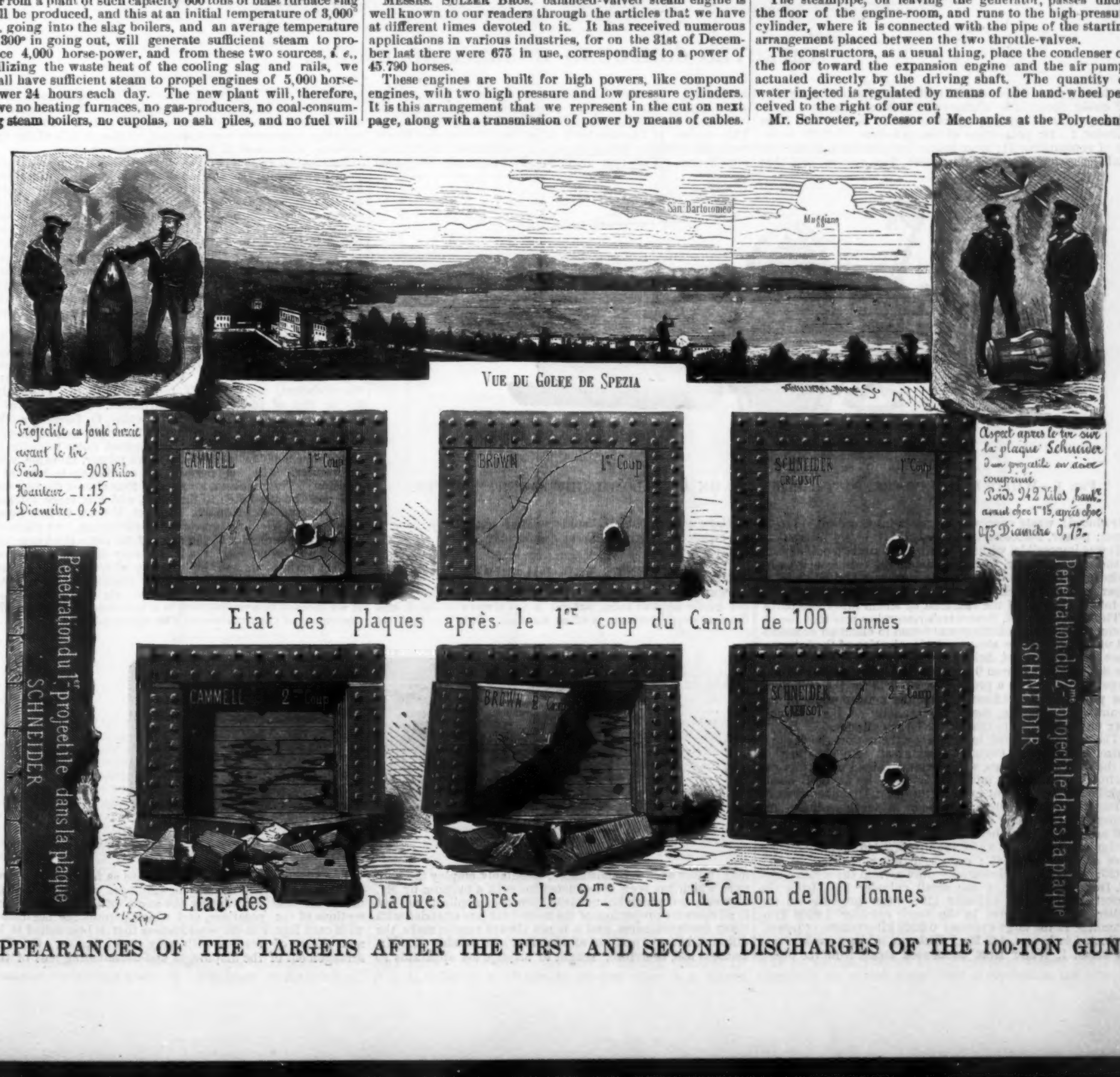
As well known, distribution is effected by means of four double-seated, balanced valves. Two of these are placed above for the admission of steam, and two below for its escape, the latter also permitting of a natural flow of the water of condensation and priming.

In each engine the valves are actuated by a longitudinal transmission situated at the height of the axis of the cylinders, and driven by the main shaft through the aid of a pair of cone wheels. This transmission is provided with two eccentrics and two cams, which act through the intermedium of a click, in such a way as to open or close the valves at the desired moment. These valves have a silent motion, resulting from the action of an air-piston, and are made so as to be perfectly tight and durable. The distribution of the small cylinder is varied by the regulator, and that of the large one may be modified by hand.

The steampipe, on leaving the generator, passes under the floor of the engine-room, and runs to the high-pressure cylinder, where it is connected with the pipe of the starting arrangement placed between the two throttle-valves.

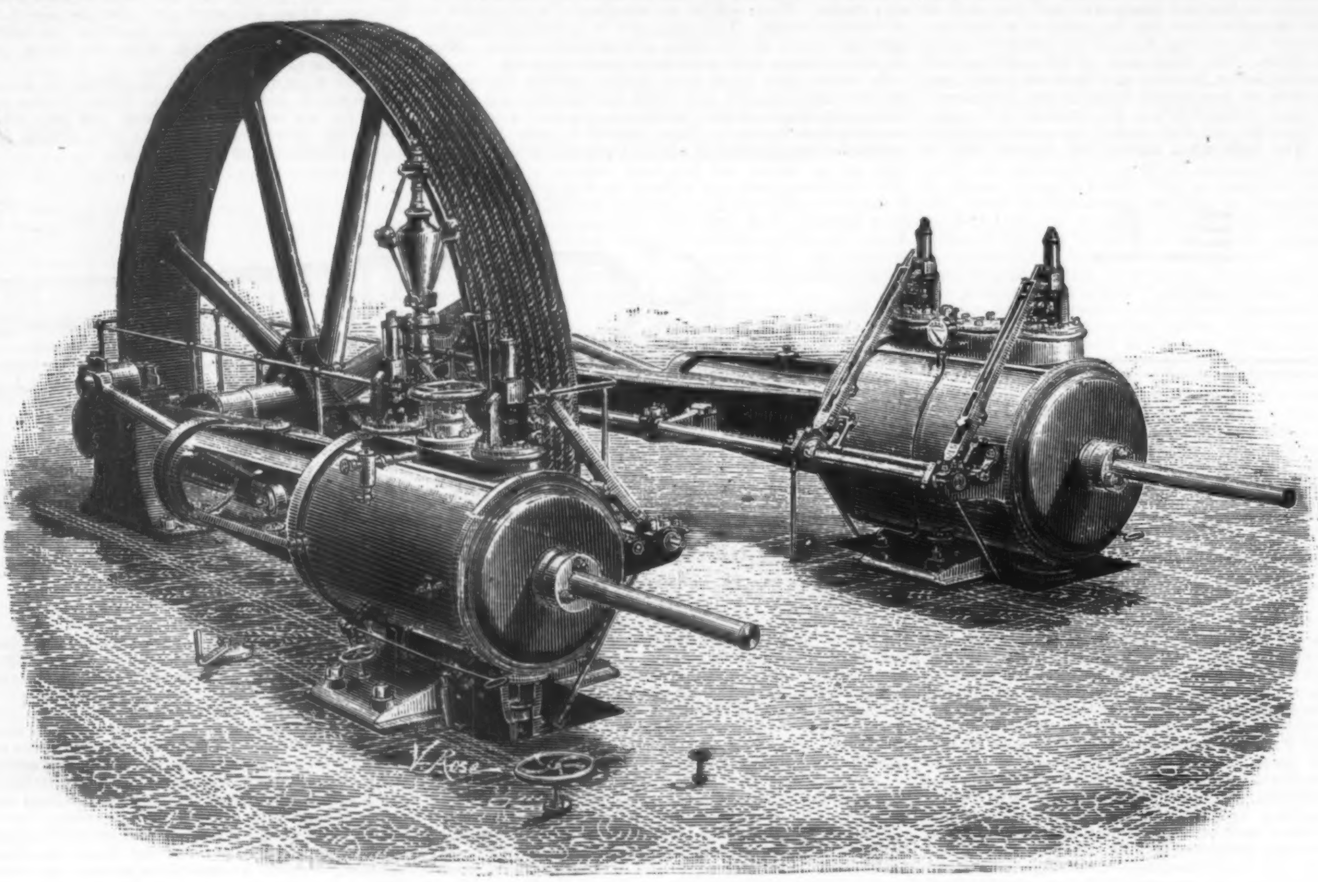
The constructors, as a usual thing, place the condenser on the floor toward the expansion engine and the air pump, actuated directly by the driving shaft. The quantity of water injected is regulated by means of the hand-wheel perceived to the right of our cut.

Mr. Schroeter, Professor of Mechanics at the Polytechnic



APPEARANCES OF THE TARGETS AFTER THE FIRST AND SECOND DISCHARGES OF THE 100-TON GUN.

School at Zurich, has made some extended experiments with one of the Sulzer compound engines built at Augsbourg, the purpose of which was to find exactly the influence of the external heating of the intermediate reservoir and of the large cylinder, through the steam from the generator, and to examine what were the limits within which the size of the reservoir has an appreciable influence upon the economy in steam. The dimensions of the engines submitted to experiment were as follows: Diameter of pistons, 370 and 611 millimeters; stroke of pistons, 950 millimeters; size of reservoir, 327 cubic decimeters; diameter of piston rods, 74·5 millimeters; ratio of capacity of reservoir to that of the large cylinder, 1 : 19; proportion of the cylinders, 1 : 2·75; number of revolutions, 71; mean velocity of pistons, 2·26 meters; total expansion (proportion between final volume and that introduced), waste spaces being taken into account, 13 to 14 times; power, indicated in horses, 150.



IMPROVED COMPOUND HORIZONTAL ENGINE.

It was impossible, without making important modifications in the small cylinder, to intercept communication between its jacket and the steam. The experiments were limited, then, to superheating the jackets of the reservoir and large cylinder, or totally cutting off the entrance of steam into these parts

The result of Prof. Schroeter's researches was that the introduction of the jacketings was found to effect an economical utilization of the steam. As for the size of the intermediate reservoir, Prof. Schroeter asserts that a variation in the dimensions of from 0·8 to 1·2 times the capacity of the large cylinder (with a proportion of 2·75 for the cylinders) has practically no influence upon the consumption of the steam. In principle, then, the capacity of the reservoir may be made equal to that of the large cylinder.

The saving effected in steam by the use of the Messrs. Sulzer's compound engine is very great. An examination of the subjoined figures, which were obtained in another experiment made with a motor of the same size at the Brussels Exhibition, is sufficient to show this fact: Diameter of small cylinder, 450 millimeters; diameter of large cylinder, 700 millimeters; diameter of piston rod, 65 millimeters; stroke, 900 millimeters; number of revolutions, 68; duration of experiments, 3·5 hours; water vaporized, 3,446 liters; temperature of feed-water, 35°; vaporized water reduced to 10°, 3,425; water of condensation—drawn from the steam pipes 16, from the jacket of the small cylinder 32·5, from the jacket of the large cylinder 119; mean pressure—in the boiler 5·6 atmospheres, in the small cylinder 1·8100 kilogrammes, in the large cylinder 0·8368 kilogramme; power, indicated in horses, 142·368. *Water at 10° used per hour and per horse*: 1. Water from condensed steam from the pipes, not deducted, 7·802; 2. Water drawn from the steam pipes, deducted, 7·765.

To sum up, in a compound engine of 200 horse power working at a pressure of 6 atmospheres, the consumption, per horse and per hour, is only 7·5 kilogrammes of steam and does not exceed 8 kilogrammes in engines of from 80 to 100 horses.

This motor recommends itself in all cases in which a saving in fuel is to constitute the dominant qualities of the application. In case of accident or repairs, it presents the merit that it may be easily uncoupled, so that one of its parts may operate like an ordinary condensation apparatus. This engine is likewise built after the two cylinder Woolf type, the cylinders being placed one behind the other on the same frame. This type may be advantageously employed in those cases in which there is want of space for putting in the compound engine.—*Revue Industrielle.*

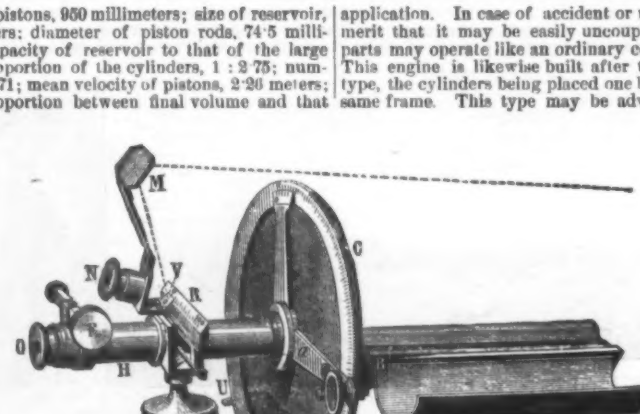


FIG. 1.—WHITE-LIGHT COMPENSATOR MOUNTED ON A YELLOW-LIGHT SACCHARIMETER.

LAURENT'S NEW POLARIMETER.

PENUMBRA polarimeters work very well with the monochromatic light of soda, but gas is not always at hand, and the necessary pressure is often wanting. It is true that we may, under such circumstances, profitably employ the colipyle which has been constructed for such a purpose by Mr. Laurent, and which has received numerous applications; but in all cases the projections of the melted salt are attended with many inconveniences, and it is not always easy to make the different burners perform all that they are capable of. Mr. Laurent has, therefore, sought to arrange his apparatus so that they may be employed with an ordinary white flame. With this end in view, he interposes a *sun compensator* (with quartz prisms) between the index plate and analyzer. Instead of operating by rotation with yellow light, the action is here performed by compensation with ordinary light. The use of the compensator has only been rendered possible by suppressing the crown prisms, that are usually cemented on those of the quartz, and by holding these latter in their mountings, without cementing, by means of light springs, in order to avoid pressure. The compensator thus modified is so arranged that it may be readily adapted to any of the penumbra polarimeters now in use. The accompanying figure very well indicates all the details of the apparatus, which may be described as follows:

The optical system consists of two prismatic quartz plates perpendicular to the axis, and of a parallel quartz plate, likewise perpendicular, but of inverse rotation. These quartz plates are always cemented upon equal and opposite pieces of glass, and the whole arrangement is cemented into a copper mounting. For the special application of this compensator or saccharimeter, Mr. Laurent, in the first place, suppresses the glasses, as their disadvantages counterbalance their advantages, and fixes the quartzes into their mounting, *without cement*, by means of springs. The angle of the two plates is determined according to the direction and extent of the rotary powers that are to be measured with the apparatus.

The two mountings are movable in opposite directions by means of racks and a milled head, G (Fig. 1). The one carries the divided rule, R, which is fixed above, and the other carries the vernier, V, a mirror, M, for lighting the divisions, and a lens, N, for reading them. The analyzer is that of the Laurent polarimeter. It consists of a Nicol prism, an objective, and an ocular, O, forming a telescope in the tube, H, as in the yellow light saccharimeter. The division and the vernier are lighted quite brightly by the burner itself by means of a small mirror, movable with the vernier. The lens permits of reading up to 1-20 of a division. The precision attained is thus almost double, and this must be attributed to the light, which is more intense, and to the use of the quartz. In fact, if there be interposed between two Nicol prisms turned to extinction, two plates of quartz, perpendicular to the axis, of the same thickness, but of opposite rotations, it will be very difficult to preserve perfect extinction, and the least imperfection in the quality of the quartzes or variation in their thickness, size, or position in the apparatus will change the original tint; so that, if we succeed in avoiding this in a polarimeter, the least displacement of the quartzes will be appreciable.

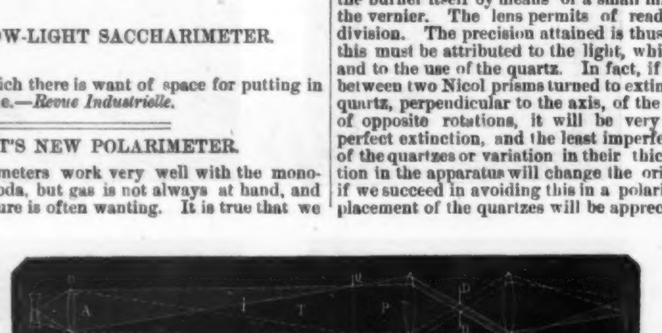


FIG. 3.

The advantages of the apparatus are as follows: (1.) Any ordinary light whatever may be employed with it. (2.) The means adopted for varying the angle of the two principal sections of the polarizer, and which permits the beginning with each liquor at the sensitiveness that is best suited to it, and allows of reading with very dark liquors. (3.) The arrangement of the diaphragm and illuminating lens of the

polarizer, which completely does away with all annoying reflections in the tubes, even those of glass, and which also obviates the annoyance of the polarizers being heated by the flame, and the zero of the apparatus getting displaced. (4.) The use of a Nicol prism as a polarizer instead of a doubly refracting prism, preventing foreign light from being introduced to diminish the sensitiveness of the image. (5.) The use of a "semi-wave" plate, whose sharp edge renders the two tints to be compared exactly tangent, and brings out the least difference between them.

Fig. 2 shows the course taken by the light. The concave lens, G, and the objective, O O′, compose the telescope with which the sighting is done. The two lenses, M and L, belong to the polarizer. When the diaphragm, Q Q′, is examined through the tubes placed at T, it is found that every point of it sends its rays to every point of the objective, O O′. These rays are the ones that are necessary to reproduce the image in the telescope. If, then, these same rays be grouped in another way, and if, inversely, we consider that each point of the objective, O O′, sends its rays to each point of the diaphragm, Q Q′, we will obtain at D D′ (by means of the lens, M) a conjugate image of the objective, all the effective rays being concentrated at D D′. If, then, we should place at this point a flame exactly the size of D D′, all the rays necessary would enter the apparatus and no others would pass; none would impinge on the sides of the tubes, and there could be no reflection there. As it would be inconvenient to place the flame at D D,′ it is placed at F, with the lens, L, interposed. It is thus situated at 20 centimeters from the lens, L, and 30 from the polarizer. For this reason, no heating nor projection of melted salt is to be feared. Mr. Laurent has profited by the smallness of D D′ to place there a thin plate of bichromate, cemented between two pieces of glass; for it is not easy to obtain fine plates of large dimensions.

The manipulation of the apparatus remains the same. The zero of the vernier, A, is placed opposite the zero of the rule, and an equality of the tones is brought about by means of the milled head, F. The alidade, *a*, is held stationary by means of the binding screw, B. The angle of the principal sections is made to vary by means of the lever, A. To obtain as much precision as possible with the apparatus, it is regulated to zero when the liquids give a deviation going from 0 to 50 degrees (hundredths of sugar); but for a deviation of 50 to 100, it is preferable to regulate the apparatus with a type-plate of quartz. This is placed on the apparatus, the vernier is turned to the division of the rule corresponding to the number inscribed on the plate, and the equality of the tone is then brought about by means of the milled head, G.

IMPROVED STEAM CULTIVATOR.

MR. JOHN D. GARRETT, of Southwold, Suffolk, and formerly of Buckau, Magdeburg, has lately constructed a steam cultivator, of which we give illustrations from *Engineering*. It is intended specially for use in the cultivation of beetroot, and is the second of the kind that has been built; it has ten forks in place of twelve in the previous one, as it was found that the latter number detracted from the handiness of the machine. Referring to the illustrations, it will be seen that the cultivator consists of a traction engine, to the rear end of which an arrangement is added for digging up the land. The engine travels slowly forward, turning up the ground behind it, and is self-moving without the aid of a rope. The wheels are driven by spur gearing upon the intermediate shafts, E, D, and can be rotated at two speeds, one for traveling, at nearly two miles an hour, and one for working, at 48 ft. 3 in. per minute, or rather more than half a mile an hour. The main wheels are each formed of twelve dished, flanged plates, P (Figs. 1 and 2), six on each side. These are bolted together through their flanges, and between them a tire is built of pieces of wood, W, over which wearing pieces, W¹, are fitted. These latter can be easily replaced. The plates, of which the wheels are composed, are flanged by hydraulic power, and a very ingenious system of dies, some of which we illustrated and described in detail on pages 25 and 26 of vol. xxviii. in connection with the Kilburn show. The wheels are driven through clutches, G¹ (Fig. 4), either of which can be released when it is desired to turn the machine at the end of a field. When one wheel is cast loose, and the steering wheels are turned to the proper angle, the engine revolves round the other wheel as on a center.

The digging mechanism consists of ten forks arranged in a row, and each moving, when the machine is at rest, in a path indicated by the dotted figure, R. This path is so designed that when the machine is traveling there is no friction between the back of the fork, or spade, and the ground. The motion of the forks is derived from eccentrics, I¹, I², I³, I⁴, fixed in the shaft, I, which is driven by spur gear upon the intermediate shaft, T. These eccentrics are arranged 90 deg. apart, so that the forks enter the ground in succession. The two outside forks make similar and simultaneous movements, as likewise do Nos. 2, 3, and 4, counting inward from each side. By this disposition there is no rocking action brought to bear upon the machine. Each spade or fork is fastened to a tubular handle, which is supported at two points. At its upper extremity it is joined to the strap of one of the eccentrics, while midway of its length it carries a bracket to which there is pivoted a link, *l*, jointed at its other end to the frame, L¹. This frame is pendent from the shaft, I, around which it can swing, and rests against the rocking frame, M. It is from the combination of the motions of the two points at which the spade-holder is supported, that its end is caused to describe the figure, R. Should it meet with some substance too hard to be cut, a spring interposed between the swinging frame, L¹, and the rocking frame, M, gives way and absorbs the motion. This latter frame is pivoted at each side to an eccentric upon the axis of the main or driving wheels, and is supported by traveling wheels, which thus constantly adapt the position of the spades to irregularities of the ground. The inclination of the spades, and consequently the depth cultivated, can be varied at will, while the machine is at work, by rotating the axle, M³, by means of a worm and wormwheel driven from a handwheel through bevel gear and inclined shafts. In the position shown the wheel, M¹, is in its nearest position to the traveling wheels, but if the eccentrics be moved round half a revolution, the wheels,

Fig. 1.

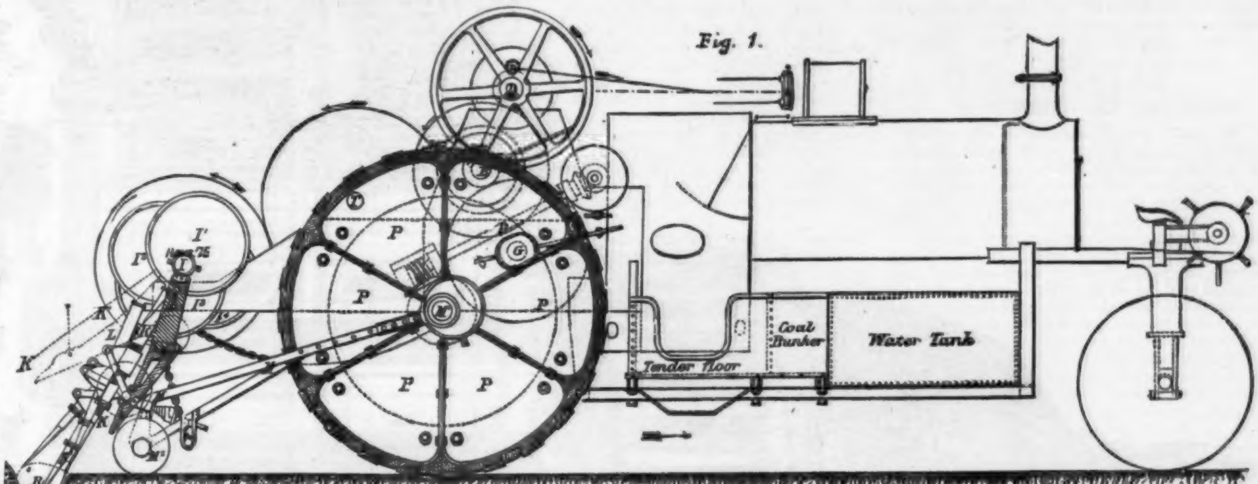


Fig. 2.

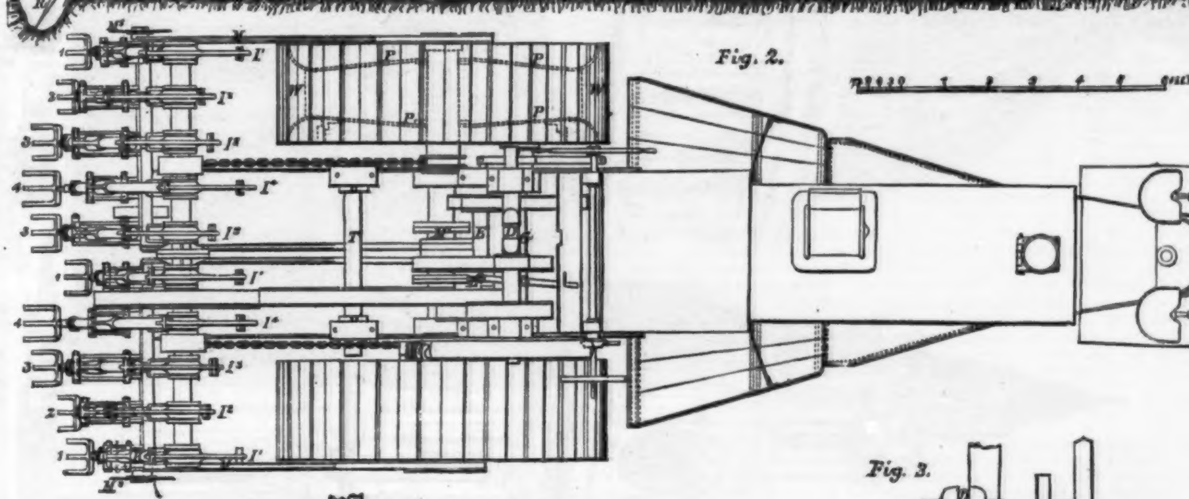


Fig. 4.

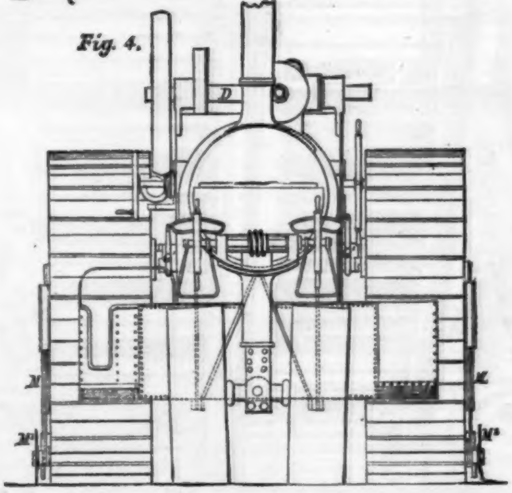
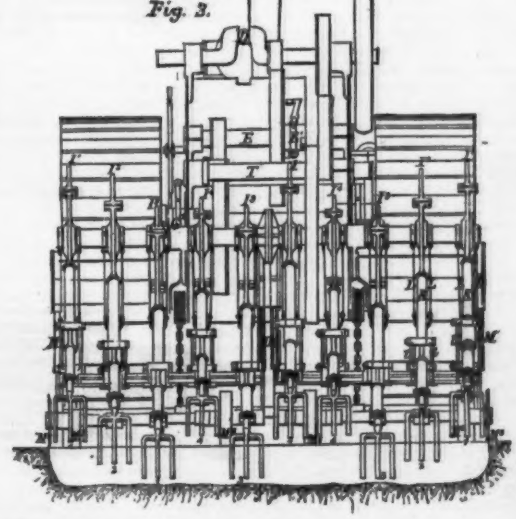


Fig. 3.



IMPROVED STEAM CULTIVATOR.

ST. PAUL'S CATHEDRAL, LONDON.—Drawn by S. Read.

M^1, are carried to the left a distance equal to the throw of the eccentric, and the inclination of the frame, L^1 is reduced. By a complete revolution of the shaft, the spades are lifted clear of the ground to the position shown in dotted lines by means of two chains that are wound upon sheaves on the axle and pass round pulleys on the main framing. There is so much slack in these chains that they do not come into action when adjustments are being made of the rocking frame, M. The bracket by which the link, *l*, is connected to the spade-holder is carried by a screw-thread, and can be adjusted upward or downward to control the movement of the spade to turn the top soil in more or less. With the parts in the positions shown, and with a speed of 75 revolutions per minute of the eccentric shaft, I, the topsoil is turned underneath. The length of the spade is also adjustable to allow for wear, and to vary the depth of the work.

As it is not intended to turn the clods over in such a way as to make a furrow, the cutting-wheels that ran between the spades in the former cultivator are not employed, and the sideways turning motion that was given to the spades as they finished their strokes is not required.

ST. PAUL'S CATHEDRAL.

OUR engraving is from the *The Illustrated London News*, from which we also take the following:

From certain points of view, the beauty of St. Paul's Cathedral, irrespective of magnitude, excels that of St. Peter's at Rome, the Duomo at Florence, and every other building in this style. It is not best seen in front; we think the southeastern view, approaching from Cannon Street, is most engaging; but the most complete view of the whole structure is that presented in our engraving, from the southwest corner of St. Paul's churchyard. It was from this point, at a house where he lodged during the progress of his work, that Sir Christopher Wren used for a time to watch it growing up, as it steadily did from 1675 to 1710, within the great architect's lifetime. Its total cost was nearly £750,000, including the architect's salary of £200 a year.

Mr. William Longman's "History of the Three Cathedrals dedicated to St. Paul in London," published in 1873, relates the manner in which this "plan handsome and noble," as it was at once pronounced to be, was gradually completed, so far as concerns the exterior, leaving the internal decoration to a future age. The west front is not what it ought to have been; it was not by Sir Christopher's design, but at the command of the Popish Duke of York, that it was encumbered with two side chapels, projecting on the north and on the south side, which lessen the apparent elevation of the towers; but the portico is grand, having two stories, the lower Corinthian, the upper Composite, like the rest of the building.

The two flanking towers have always been admired by architectural critics. The upper part of the sides is only a screen to hide the flying buttresses which have to withstand the thrust of the main vaulting, over the nave, choir, and transepts. It is well known, also, that the majestic external dome, with its diameter of 145 feet, surmounted by the stone lantern and lofty cross, is not the dome seen in an interior view. The inner dome, of brick, has a diameter of 108 feet; and the large space above, between this and the outer dome, is occupied by a conical superstructure which really supports the lantern and cross, while the outer dome, which is a shell of timber covered with lead, only seems to do so.

As a contrivance of engineering skill, this peculiar arrangement has great merit; but the purists of architectural sincerity may be inclined to regard it as a sham. The architect had intended, we learn from the "Parentalia," or memoirs written by his grandson, to make the dome of moderate height externally, corresponding with the interior; "but the old church having had, before, a very lofty spire of timber and lead, the world expected that the new work should not, in this respect, fall short of the old; though that was but a split, and this a mountain.

"He was, therefore, obliged to comply with the humor of the age, and to raise another structure over the first cupola; and this was a cone of brick, so built as to support a stone lantern of elegant figure, and ending in ornaments of copper gilt. As the whole church above the vaults is covered with a substantial oaken roof and lead—for no other covering is so durable in our climate—so he covered and hid out of sight the brick cone with another cupola of timber and lead; and between this and the cone are easy stairs to ascend to the lantern." It is, however, universally acknowledged that the exterior dome—surrounded at the base with a circular colonnade of thirty-two pillars, above which is a fine gallery, with an Attic order of pilasters—has unsurpassed grace and beauty of form.

LUCA DELLA ROBBIA.

THE Museum of Art, whose prosperity during the past two years has been a subject of congratulation to the city and country, has acquired a work of the highest importance, which demands more than passing notice, not alone for its great value, but also because it shows the error of a common saying that the European museums have gathered all the great works of the mediæval and cinquecento artists. This acquisition is a grand work by Luca della Robbia, in enameled pottery, an "Assumption of the Virgin." The whole work is ten feet high by seven in breadth. It was executed for the mortuary chapel of the family of the Princes of Piombino, and has remained in Italy until transferred to the Museum in New York, where it has been admirably placed by the Director in a decorated alcove. It is a gift to the Museum by Henry G. Marquand, Esq., one of its trustees, and adds another to the already vast and priceless collection of art objects which a small number of gentlemen and ladies have gathered and are exhibiting for the instruction of the people.

This work has long been recognized as one of the noblest productions of Luca. It ranks as equal to any known work, and is in some respects the most important and valuable of his enameled potteries which have passed into possession of public museums. Like most of the Robbia works it is a relief, in white on a blue background, with touches of other colors. Luca was always sparing in the use of other colors than blue.

The subject is inclosed in a richly ornamented arch, which is as important an illustration of ceramic art as the relief group itself. The columns, one at each side, which support the arch, are decorated with reliefs of great beauty. Between the columns stand four ecclesiastics, two on either side of the sarcophagus, which forms an altar, covered with green leaves and white flowers. Above this the Virgin appears with hands lifted, palm to palm, surrounded by cherubs and attended by groups of angels with trumpets. High over her two angels floating in the sky hold between them the crown. This elaborate work consists of no less than ninety-three sections, which are fitted together. A critical examination may lead to the suggestion that a small number of the sections are of later date than Luca, and that the work was completed after his death, or that broken portions of the original work have been replaced by later potters. These are very few, however, and the work as it stands has received the certificate of its genuineness from the highest authority in Italy, a certificate which was hardly necessary in view of its known history. The mitered figure at the left represents St. Francis, known by the stigmata on the hands. The other monks are probably members of the Piombino family.

Every one knows that the art of enameling pottery is supposed to have been introduced into Italy by Luca. He must have obtained it from a Saracen potter. Like sculpture it was an ancient art, and its genealogy is complete. The Saracens had found it, probably in Persia, when the Arab hosts carried Islam into the land of the Sassanians. There, doubtless, the art had existed since the time of Cyrus. The Assyrians had received it from Egypt, where it was practiced four thousand years ago. It is a very simple secret, the use of an oxide of tin; but there is no evidence that the art of enameling pottery has ever been practiced except by those who have learned it from some one who learned it from the old Egyptians. It is probable that China received the art across Asia from Persia. It went to Germany, possibly from Constantinople, before Luca introduced it in Italy. It is a curious fact that although Luca made enameled pottery shortly after the middle of the fifteenth century, the taste of Italy did not lead the potters to adopt it for decorated wares till nearly a half century later, and they went on making painted and glazed wares for the market and for ornamental uses.

It is possible that Luca had a peculiar enamel of his own, of which he preserved the secret, and this may have given rise to the story that he handed down this secret to Andrea and his other successors. But there is not sufficient uniformity in the enamels of his various works to confirm beyond dispute the idea that he had any such special composition; and the art was no secret, for Saracen potters practiced it in various places on the Mediterranean.

The Museum of Art is peculiarly fortunate in this acquisition. It belongs to a period in the modern history of art which bears close analogy to that period in ancient art history of which the Cypriote sculptures and potteries are the authoritative illustration. These were transition periods in both cases. The Assyrian and Egyptian products of art had been works made not to represent known objects, nor to picture the supernatural by painting or carving copies of the natural. They spoke to the imagination, and aroused it. They represented qualities rather than forms. Mystery, grandeur, power, strength, cunning, these and other characteristics were illustrated by the artist and suggested to the mind. In later times the Greek represented his god by a statue of the highest type of the human form which the artist could imagine. The transition from one class of art to the other is abundantly shown in the Cypriote sculptures, where the Greek is exhibited learning from the Phenician the old arts of Egypt and Assyria, and modifying them according to a new code which was slowly forming.

So in mediæval Europe, art, in what is commonly but erroneously called the dark ages, while exercising no mean powers, sought to illustrate and did illustrate thoughts rather than facts, emotions rather than persons moved by emotions. In studying this art, superficial and uneducated critics make the error of judging by a modern standard of what is called "the beautiful." This is absurd, and is one of the follies of the modern æsthetic school, which is, in the main, a very poorly informed school. The refined and educated mind of the middle ages found the beautiful for itself, and had as good right and ample power to define beauty for its tastes and create it for its standards, as the nineteenth century can claim. In the fourteenth and fifteenth centuries a change in tastes and desires, and a corresponding change in productions, of art, took place, in many respects resembling the one noted in ancient art. The pictures of the earlier artists illustrated emotions, hope, devotion, penitence, faith, but the human forms used as the foundations were not flesh and blood; were forms no man would dream of embracing—faces sometimes wondrously beautiful to our view, but which no imagination would think of insulting with a kiss. The change, called the renaissance, which was the revival of the old Greek realism, went on for more than a century, until its culmination when Raphael satisfied the art conception of his and later times by painting the portrait the fat and fair wife of the cooper to be the renowned Madonna of the Chair. During this change, Luca della Robbia, born about 1400 and living fourscore years, exercised, probably, more influence on his age and later ages than any other sculptor. His works, like the late Phenician and early Greek statues, show the old art tastes as well as the progressive change toward the new. He clung to the old, restrained the demoralization of art toward which the new was tending, yielding slowly, as every artist must yield, to the demands of the age and its new education and desires. But there are no works of the later school in which the emotional character is so strong. This is perhaps the reason for the remarkable fact that photographs of his works usually appear to modern tastes more beautiful than the original stone or pottery. He was the great artist of the fifteenth century, and examples of his works have become so desirable for their educational importance that the smallest and least striking are valued at thousands of dollars. It is but a few years since it was said publicly that the Museum of Art could not hope to secure a genuine Luca. We congratulate it on the possession of one which has, perhaps, no superior in the world.—*N. Y. Journal of Commerce.*

PROCESS FOR LETTER COPYING.

THE process utilizes the well-known glue plate, consisting of glue, water, and glycerine, but with rather more glue than in the hektograph. For writing, a strong alum solution is used, colored slightly with an aniline color to render it visible. The glue plate is moistened with a sponge, and, after a few minutes the written paper to be copied is laid down upon it; in taking it off after a minute or two the characters are seen to be etched or engraved in the glue. By means of a caoutchouc roller a little printer's ink is spread over the plate. Impressions may then be taken off on slightly damp paper. The ink roller requires to be passed over previous to each impression being taken. An improvement has also been made by J. Lewitus, in Vienna, in the ordinary hektograph, so that the writing can be rubbed off the glue plate as easily as chalk from a black-board.

Herrn O. Lehn, of Charlottenburg, has also recently patented an improved copying apparatus, in which a specially prepared moistened paper is stretched in a frame, the original writing is placed upon it and left for one or two minutes; after removing it again, the negative or prepared paper is spread over with ink, and the copies are taken. The following process is patented by Komaromy, in Buda Pesth. The following mixture is painted over paper impervious to water:

Gelatine	1 part.
Glycerine	5 parts.
Chinese glycerine	0·2 part.
Water	1 part.

The manuscript is written with the following solution:

Water	100 parts.
Chrome alum	10 "
Sulphuric acid	5 "
Gum arabic	10 "

and then laid on the first paper. An aniline color solution is now poured over it, and the excess removed with silk paper. Those parts which have been touched by the prepared ink become hard and incapable of taking up the aniline color solution, and the remainder becomes deeply colored. By placing clean paper over it, negative impressions are obtained.—*Journal of Chemical Industry.*

[N. Y. SUN.]

A HISTORY OF PAPER.

UNDER the above title Messrs. Clark W. Bryan & Co., Holyoke, Mass., have published an interesting monograph, setting forth the origin and manufacture, the utility and commercial value, of what has come to be an indispensable staple of the commercial as well as the literary world. The author, Mr. J. E. A. Smith, has shown a creditable amount of research in that part of the essay which deals with the ancient and mediæval substitutes for the modern paper manufactured from vegetable pulp, and appreciates the true relation of those materials to the invention of printing by means of movable types. It was De Quincey, we believe, who first pointed out with an adequate degree of emphasis that the true revolutionizing agent was not the displacement of the pen by the type, but the supersession of parchment by a cheap hand-made paper. To say nothing of the fact that whenever the Egyptians, Greeks, or Romans used seals to produce impressions, they had already grasped the essential principle of printing by movable types, we now know from the inscribed bricks unearthed upon the sites of Babylon and Nineveh that long histories were printed thirty centuries ago by the inheritors of the Chaldean civilization. It is true that in the case of these bricks the impression was embossed by moulds instead of being colored by ink, but, as Mr. Smith observes, the process deserves the name of printing as truly as does our method of preparing books for the blind. There is reason to believe that the printers of cuneiform characters upon bricks had movable moulds or types, each separate character being apparently inscribed by a mould provided with a handle whereby it was deftly taken from a set which answered the purpose of a modern printer's case. Mr. Smith recognizes a still nearer approach to what is understood in modern times by printing in the figures and hieroglyphics inscribed with heated metal brands upon the bands of red leather which surround the foreheads of some Egyptian mummies. In connection with these approximations to the invention of printing, the author of this treatise mentions the suggestive fact that the ancients who employed papyrus to write upon had, besides a writing ink used with a reed or quill pen, another more viscous substance which was applied with a stiff brush, and must have closely resembled printing ink. Pliny describes it as made from soot mixed with burnt pitch and resins, which correspond very nearly to the lampblack, resin, and vegetable oils which form the chief ingredients of modern printing ink.

It is probable enough that the first purpose for which paper or some substitute therefor was required was the transmission of short and simple messages. This purpose would be answered by any tolerably smooth and light substance, and the smooth bark or the broad leaves of certain trees would, generally, prove most available, though thin sheets of metal, ivory, or leather and painted cloths, stones, and bricks have been made to serve the same end. As the wants of a community became more complex, and materials for records as well as for messages were desired, inscribed leaves would be strung upon threads for preservation, the bark of trees would be made so pliant as to admit of being rolled, and the wood itself would be cut into thin strips, and sometimes covered with a coating of wax. On the American continent the Aztecs, who had attained to a system of hieroglyphical writing, not only used cotton cloth and skins for their manuscripts, but, according to Prescott, manufactured from the leaves of the aloe a true paper, which, when properly dressed and polished, resembled the Egyptian papyrus. Although, however, recourse had been made to numerous other substitutes, papyrus and parchment were the materials which chiefly supplied the place of paper among those nations of the Mediterranean world from whom our civilization has been derived—the experience of China being in respect of paper, as of many other inventions, isolated and exceptional.

The plant which the Egyptian called bublos, and which we know by the Latinized Greek name papyrus, grew to the height of ten feet, and very abundantly, in the overflowed lands and marshes of the Nile. It has now become rare, owing probably to the cessation of culture and protection. The stalk of this plant, which is properly styled a reed, is triangular and bare, except near the root, where there are some small leaves; the top is surmounted by a bushy head of fibrous foliage, spreading out in the shape of our common feather dust brush. The reed was clipped annually, about eighteen inches of the lower part of the stalk being sold for food, and the remainder being devoted to the paper manufacture. The stalk consists of twenty-three folds, varying in fineness of texture from the coarse exterior bark, which is only used for cordage and the purposes for which hemp is now employed, to the delicate fiber which formed the coating nearest the pith. The manufactured papyrus was of nine different qualities, distinguished mainly by the raw material selected. The coarser grades were sold by weight, and used only for wrapping paper, while the finer sorts, so long as Egypt was an independent monarchy, were reserved for religious books.

The process of manufacturing papyrus involved the use of no machinery, nor did it call for any intelligent application of chemical science; it was purely a mechanical preparation of the substance wonderfully adapted by nature to the purposes for which it was required. The folds in the tissue of the stalk were first separated by an instrument sometimes called a needle, and sometimes a sharp stone. A

layer of one class of these folds was then placed upon an inclined table of wood, wet with the water of the Nile, and the rough ends were cut straight. Across this a second layer was laid at right angles, and sometimes a third at right angles with the second. Where the folds were imperfect they were patched, the adhesive power being supplied by a glutinous substance which the Egyptians believed to belong to the Nile water, but which really resided in the raw papyrus itself; the same glutinous quality caused the layers to adhere when they were subjected to the pressure which was the next step in the manufacture. After this the compressed layers were dried in the sun, and a firm, hard sheet having thus been obtained, any roughness in it was beaten smooth with mallets, while the surface was polished by hand with a semi-cylinder of stone, glass, shell, or ivory. The width of the papyrus sheet was determined by the length of the section of the papyrus reed employed; the specimens found vary in breadth from five to eighteen inches. The length might be indefinitely prolonged, sheet being fastened to sheet by the inherent glutinous property, aided by paste or some species of glue. When finished, the sheet of papyrus paper was rolled upon a wooden cylinder, whose ends projected. The longest roll yet discovered is thirty feet in length.

The date at which this species of writing material was first used is unknown, but it was certainly employed as early as 2400 B.C., and it continued to be used for the official papers of the Papacy as late as the twelfth century of our era. It is also impossible to fix the date of the first use of parchment—the general name for the skins of certain animals when prepared to write upon—but there is no doubt that it must have been known to the Greeks and Persians before the sixth century B.C.

If the term paper, in the narrow sense, is limited to a material manufactured of rags or other vegetable fiber reduced to a pulp, there can be no doubt that the credit of the invention belongs to the Chinese. According to some historians it was made in China as early as the year 156 B. C., while according to others the introduction of the fabric should not be placed earlier than the year 200 of our era. It is undisputed that four kinds of paper have been made in China since the later of these dates, and from that time to our own there has been but little change in the processes of manufacture. These papers are known as rice, silk, bamboo, and bark. The first is made from the pith of a leguminous plant, imported from India and from the island of Formosa. The pith, having been prepared of the length desired for the sheet, is cut in a thin slice, which is then flattened, pressed, and dried. This delicate material, which is used for writing and printing, as well as for painting, gets its name not from the substance of which it is composed, but from the sizing of rice water which it receives. The so-called silk paper of China is also a misnomer, for it is made from cotton and linen rags, hemp, unmanufactured cotton, and the like, sometimes mingled with wood pulp and bamboo pulp, and possibly with a little silk. But silk rags could not by themselves be reduced to a pulp suitable for making paper. The rags, cotton, and hemp are prepared by being cut and well washed; they are then bleached, and by a maceration of twelve days' duration are converted into a pulp. This is made into balls weighing about four pounds, which, after being saturated with water, are spread upon a frame with reeds, and pressed under heavy weights. The drying is completed by hanging the sheets upon the wall of a room, and the process is finished by coating them with a gum sizing, and polishing them with some smooth, hard substance. The sheets of this so-called silk paper, which, as we have seen, is mainly cotton paper, are sometimes of very large dimensions, reaching, for example, twelve feet in length and in breadth. Of the so-called bark paper we need only say that it is made from the inner bark of the smaller branches of a variety of the mulberry tree. This bark is wrought into a pulp, and then moulded into sheets, which, after compression and drying, form a material which will take ink, though it is even more delicate than the "rice paper." The bamboo paper, as the name implies, is made from the fiber of the bamboo plant reduced to a pulp, which is formed into sheets and subsequently compressed and dried.

The art of paper making spread from China throughout Central Asia, and it was found there about the beginning of the eighth century by the Saracens, who brought it to Spain. The material chiefly used by the Spanish Moors was raw cotton, and the manufactured product was accordingly yellow and brittle; but about the close of the eleventh century some Christian Spaniards, who had learned the art of paper making, substituted cotton rags, and not long afterward made the further improvement of stamping the rags into pulp by water power. By the close of the twelfth century cotton paper had come into general use in southern and western Europe, but as it was then made it did not possess sufficient strength or solidity for many purposes, and by the close of the fourteenth century it was almost entirely superseded by paper made of hemp and linen rags. It was the introduction of this strong, and yet reasonably cheap, linen paper which gave a powerful impulse to the introduction of printing by means of movable types.

Although it is known that a papermill existed in England toward the close of the fifteenth century—there is, indeed, some evidence of paper making there as early as the beginning of the fourteenth—it was long before the manufacture flourished in the island of Great Britain, and it was not until 1690 that some Huguenot refugees who had settled in England began the manufacture of white writing paper. Nor was it until the close of the eighteenth century that the English fabrics were equal to those of the Continent. The first paper mill in America was established in 1690 by William Rettinghuysen (anglicized into Rittenhouse) and William Bradford on a small stream near Philadelphia, still called Paper Mill Run. The second paper mill in the United States was built in 1710 at Crefeld, now a part of Germantown, and in 1728 the third paper mill in Pennsylvania was erected by some apprentices of Rittenhouse. By 1770 there were in Pennsylvania, New Jersey, and Delaware—then the chief seats of the paper manufacture—forty mills, whose annual product was valued at about $350,000. Massachusetts, Rhode Island, and Connecticut had five paper mills between them, and in New York there were at least two. Before the Revolutionary war American paper was usually made of linen rags. Every household in the Northern colonies then spun and wove linen from the flax grown upon almost every farm, and it was used for the purposes for which cotton is now chiefly employed. After the Revolution paper mills multiplied, and at present the number of paper and pulp factories in the United States is 1,040. The principal seat of the American paper manufacture is now in the four western counties of Massachusetts, a region whose flourishing cities and towns are largely dependent on this industry for their prosperity. For an account, however, of the numerous improvements which have been made since paper was first manufactured by machinery we must refer the reader to Mr. Smith's monograph, in which the subject is discussed with thorough knowledge and in adequate detail.

A MODIFIED GELATINE EMULSION PROCESS.*

I PURPOSELY avoid entitling the modification which I propose to describe to you to-night a new process. Although, so far as I know, it has never before been published in a practical working form, yet I am aware that the principle on which it depends has often been noticed. This is nothing other than the property which an emulsion made by the so-called "boiling" process exhibits when, after the heating has been continued for long, the bromide of silver commences to settle to the bottom of the vessel.

I believe I shall best make you understand the process by explaining, as briefly as possible and without comment, the method which I follow in making an emulsion, after which I shall go over a few of the more important points in detail, and then describe to you what I conceive to be the advantages of the process over those usually practiced:

A—	Potassium bromide	340 grains.
	Nelson's No. 1 gelatine	60 "
	Water	20 ounces.
	Hydrochloric acid, enough to render the solution very slightly acid...about	2 minims.
B—	Iodide of potassium	10 grains.
	Water	1 ounce.
C—	Nitrate of silver (dry)	400 grains.
D—	Ammonia, 0·88	¼ ounce.
	Alcohol	1 "
E—	Heinrich's gelatine	360 grains.
	Water	20 ounces.

I place A in a hock bottle, and warm till the gelatine is melted. I then add the dry nitrate of silver in one quantity, and shake up till I know, by the sound of the crystals striking the bottle ceasing, that they are all dissolved and emulsified. I now add B. The next operation is precisely similar to that which is usual in the boiling process.

The emulsion is poured into any convenient vessel, and boiled for about fifty minutes; it is then allowed slowly to cool to 120° F. D is now added, and the whole allowed to stand for forty-eight hours. At the end of this time the supernatant fluid may be poured off almost quite clear; twenty ounces of water is again added, the bromide being stirred into it. The whole is once more allowed to stand for forty-eight hours, when the water is again poured off. The bromide of silver I now consider to be sufficiently washed. E is added, the vessel is warmed, and the emulsion is complete. Two ounces of methylated spirits with twenty grains of salicylic acid dissolved in it, and four or five minims of ammonia, to counteract the acidity of the gelatine, are added. The emulsion should be kept a few days before coating plates with it.

I now propose to go somewhat into detail in regard to one or two points. First, as regards the formula used. I may say that any one suitable for the boiling process will do. The only thing noticeable about the quantities in the formula which I give is the large amount of water used. This I consider very important. There appears to be a general impression that the amount of bromide of silver which a given weight of gelatine is capable of suspending is greater if the quantity of water be reduced, so as to make a comparatively concentrated gelatine solution. To take an example, it is, I believe, the general opinion that if the sixty grains of gelatine above mentioned be dissolved in six ounces of water, so as to make a ten-grain solution, it will suspend more bromide of silver than if it be dissolved, in thirty ounces of water to make a two grain solution. The very reverse is the fact. The more a gelatine solution is diluted the more bromide of silver may be suspended in it, and that in a finer state of division.

In most formulæ the addition of a large quantity of water is objectionable, as the emulsion will not afterward set sufficiently stiffly to allow it to be washed. With the process under consideration the objection does not hold. With the quantity of water given it is *impossible* to get other than a finely divided emulsion of a ruby color by transmitted light, however carelessly the mixing be performed. I therefore adopt the very simple method of dropping the silver in one mass into the bromide solution, and shaking till the former is dissolved. It will be seen that an emulsion in a very fine state of division, and of a ruby color, is the result.

I add the iodide in a separate solution afterward, for the reason given by Captain Abney—that by so doing the iodide will be in the same state of division as the bromide, the iodine of the iodide replacing so much of the bromine of the already formed bromide of silver.

As regards the time of boiling, I give fifty minutes as an average time. Very insignificant modifications in conditions, however, considerably alter the time necessary, and in practice I always judge by color, boiling till there is only a trace of red left in the bromide. I find that the time taken varies from forty minutes to an hour and a half.

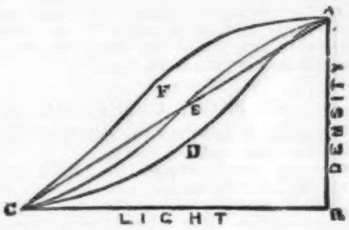
We now come to the question of the addition of the ammonia, which I consider the most important part of the process.

Most of you are acquainted with a formula which, I believe, is due to Dr. Eder, in which it is recommended that boiling be first resorted to, and that afterward the emulsion be treated with ammonia. Captain Abney has stated that the subsequent treatment with ammonia is of no use, as it does not increase the sensitiveness, while it endangers the quality. My experiments lead me to the conclusion that in a certain sense he is right, while in another he is wrong. The action of ammonia on an emulsion is peculiar, and I do not think I can explain it except by resorting to a graphic method.

If I represent, as on the diagram, light by a horizontal line, and density by a vertical line, it is evident that if a negative were absolutely correct—that is to say, gave a gradation of density exactly proportionate to the gradations of light in the subject—that negative would be represented by a straight line, C A.

I believe no sensitive substance has been investigated which will give such an absolutely correct negative; but that, on the contrary, all sensitive substances will give gradations represented by curves more or less nearly following the course of the straight line, C A.

With a boiled emulsion, the curve representing density will follow a course something like C D A. On the other hand, in the case of an ammonia nitrate emulsion, the curve will be like C F A. Now, inasmuch as these curves both commence at the same point, plates which are represented by them will, if exposed under a sensitometer tablet and afterward developed, each show the same last figure, and, if judgment be taken by reading the sensitometer in the usual way, will both pass as of the same sensitiveness. Let them be exposed in the camera, however. It is quite evident that no exposures can give precisely similar results; but to get what is somewhat indefinitely described as a well-exposed negative in each case will require for the plate, C D A, a much longer exposure than for C F A. I have known plates giving the same sensitometer figures but requiring camera exposures varying as four or five to one. On the other hand, plates requiring the same camera exposure may show differences to the sensitometer of five and six figures. I am here not taking into account the effects of pre-exposure, whereby it is possible to get, within limits, any figure of the sensitometer with a plate of any sensitiveness.



There is an objection, however, to the very high curve, C F A, inasmuch as it is a very great departure from a correct rendering of the intensities of light reaching the plate, although it is more like that given by collodion, which is so often and so incorrectly held up as a model to dry plate workers.

It is possible, however, by a combination of the boiling and the ammonia processes, to get any curve between the two extreme ones which I have given. I believe that, with the formula given above, a curve very like C F A is obtained; and that is as near an approach to the hypothetical straight line as it is possible to come.

I have always, previous to this, deprecated the use of ammonia in the making of emulsions, because it is liable to give rise to green, red, brown, and other fogs; but with the process in question this drawback is entirely overcome, inasmuch as the bulk of gelatine never comes in contact with the ammonia at all. I have never had a case of green fog in plates coated with emulsions made as detailed.

The alcohol is added with the idea that it will prevent the possibility of decomposition—or, rather, putrefaction—of the gelatine. I believe it is not very necessary.

With regard to the washing of the precipitated bromide and iodide of silver, of course there is no objection to stirring it with water twice, and allowing it to settle altogether three times; but I find that, with the amount of washing recommended, the whole of the free bromides, as well as the nitrate and the ammonia, are practically got rid of.

In giving forty-eight hours as the time necessary for the bromide of silver to settle, I consider that I am making a very ample allowance. The time taken is naturally very much modified by the form of the vessel used; it, moreover, varies with conditions which I have not been able to discover. I may say that, on an average, the bromide settles at the rate of about an inch in six hours. Forty-eight hours would thus allow for a vessel eight inches deep. The one I now use has about six inches of fluid in it, and it would take an average of about thirty-six hours for the bromide to settle. Often, however, I have known it to take less than half that time.

It will be evident that the use of a shallow vessel will cause the precipitation to take much less time. There are, however, obvious objections to the use of a shallow vessel. I think it quite likely that means may be discovered of causing the precipitation to take place far more rapidly than I have described. The fact that occasionally the bromide will settle without the addition of the ammonia, while at other times it will not, even when the circumstances and treatment are apparently the same, shows that the matter is not thoroughly understood as yet.

I now come to the mixing of the gelatine with the bromide of silver to form the emulsion. Here it is just possible that, by carelessness, the operator may fail to so mix the bromide and the gelatine as to get a fine state of division. He cannot, however, fail, if he follow the method which I now show. I have here, in one glass beaker, 360 grains of hard gelatine soaked in twenty ounces of water; in the other I have the bromide of silver with the washing water still over it. I pour the water away, and you will see that it is almost colorless, and that it is necessary to leave only the smallest quantity conceivable, to prevent any of the haloid from coming over with it. I now plump the twenty ounces of water and the 360 grains of gelatine into the silver haloid. I take a glass rod, and twist the gelatine round the end of it. With the kind of mop thus formed, I scrape the bromide and iodide of silver from the bottom of the vessel, while I gently apply heat. When the gelatine is melted, the emulsion is complete.

I have tried the result of varying to a very considerable extent the proportion between the bromide of silver and the gelatine in emulsions made as described, and find that there is remarkably little difference in sensitiveness between an emulsion rich in silver bromide and one poor.

I have divided the precipitated bromide of silver, and to one-half have added double as much gelatine as there was dry bromide, while to the other portion I have added only half as much gelatine as there was bromide. Plates were coated with these emulsions—one containing four times as much gelatine as the other. In each case the plate was coated until it was thought to be sufficiently opaque. This took, of course, much more emulsion in one case than in the other; in fact, the quantity of bromide of silver on each plate would be approximately the same. On exposure and development, the one plate was scarcely distinguishable from the other. That which had the least gelatine in it showed, after fixing, somewhat of a better color of image than the other, which, by the way, took an inordinate time to fix.

Only one point still deserves mention, and that is the effect of keeping the emulsion. Some considerable time ago Captain Abney pointed out that emulsions improved by keeping. I have found this to be so in some cases, but not in others; and I have been quite unable to find any rule to account for the action of an emulsion on keeping it for a length of time. I have known an emulsion to increase in sensitiveness several times when kept for a week, while another, prepared by precisely the same formula, did not change, or even grow slower. The change is more likely to take place

* A communication to the Photographic Society of Great Britain.

if the emulsion be rendered slightly alkaline. With the formula which I have just given, I have never known an emulsion fail to get very considerably more rapid on keeping it a week, while the density appears to increase even more than the sensitiveness. I have known an increase of sensitiveness, represented by a ratio of quite four or five to one, take place in a week. Those who try the process must not, therefore, be disappointed if plates coated immediately after preparation are thin and not exceedingly rapid. After keeping for a week or ten days, the emulsion will make plates of the very highest sensitiveness, and giving ample density.

The fact that increase in sensitiveness is so very marked in this process would tend to show that time is necessary to let that combination between pure bromide of silver and gelatine take place, which possibly accounts for the extraordinary sensitiveness of a gelatine plate.

I now come to consider what I believe to be the special advantages of the process. I have pointed out, as a minor advantage, that as much water as is desired may be used in emulsification. A further advantage is to be found in the fact that, unlike other precipitation processes, the operations gone through to give sensitiveness are exactly the same as those which are used in ordinary cases, and with which all emulsion workers are familiar. I think that most will find it a decided convenience to be able to do away with the washing of the finished emulsion, and to put in place of it the simple operation of decanting some water and again filling up the vessel.

The great advantage, to my mind, of this process over most others lies in the fact that the gelatine, which has gone through the ordeal of the operation necessary to obtain sensitiveness, is eliminated. It is this gelatine which I believe gives rise to many of the evil phenomena which gelatine plates exhibit, especially when ammonia is used.

Of course, I do not recommend the method I have described for use in cases where it is desired to obtain an emulsion in the shortest possible time; but for regular day-to-day working, as in the case of commercial plate-makers, I can conceive of nothing more convenient, while there is, at any rate, no process capable of giving *better* results.

In systematic working, the emulsion which was made to-day would be set on one side, that which had been made the day before yesterday would be ready for decantation; while that which had been made four days before would be ready for mixing with gelatine, and setting on one side to ripen for as long as the photographer thought fit.

I may say that, following advice given by Mr. A. Cowan, I am pouring each emulsion, as it is finished, into a large stone jar, there to lie till the vessel is full, when I shall commence coating plates with it. The alcohol and salicylic acid added prevent decomposition from taking place.

I imagine that the bromide of silver formed in the process might be dried and kept indefinitely. I have not tried this. I have tried to emulsify it with collodion, but with little success. The very slight nature of my experience with collodion emulsions may, however, account for this.

I pass round one or two plates which were coated with the very first emulsion which I made by this process.

The following will be found to be a suitable alkaline developer for plates made by the method which I have just described:

Pyro	1 to 2 grains.
Ammonia bromide	1 grain.
Ammonia, 0·880	3 minims.

to each ounce of developer.—*W. K. Burton, in Br. Jour. of Photo.*

PAPERS UPON INDUSTRIAL CHEMISTRY.

By DR. ALBERT R. LEEDS.

I. UPON THE ANALYSIS OF SOAP.

IN the analysis of soap it is necessary to determine: 1. Water; 2. Uncombined fat; 3. Soap, consisting of (3*a*) combined fatty acids and (3*b*) combined alkali, usually soda (Na_2O); 4. Uncombined alkali; 5. Glycerine; 6. Resin; 7. Sodic carbonate; 8. Sodic chloride; 9. Sodic sulphate; 10. Sodic silicate, consisting of (10*a*) soda combined in silicate, (10*b*) silica; 11. Starch; 12. Insoluble residue or mineral impurities, such as talc, clay, ocher, sand, etc.

METHODS OF ANALYSIS.

Various methods have been proposed, which can be best understood by presentation in the original language of their authors, along with such comments as have been suggested by my own experience. These notes are bracketed to distinguish them from the original text. In conclusion, I have ventured to propose a new method, which has been found to give accurate and rapid results, and has the advantage of reducing the performance of a soap analysis to a few consecutive operations and one weighing of the original sample.

METHOD I.

Published by C. F. C. in the *Chemical News*, vol. xxxv., p. 2.

Weighing.—In all methods usually given in text-books, the analyst is directed to weigh out for each operation small portions (1 to 5 grms.) of the sample. This plan is to be avoided, and for two reasons: 1. Soap is extremely variable in composition, and considerable variations are possible even in the same sample. 2. It is perpetually losing water by evaporation from its surface. As the soap is usually weighed in the form of thin shavings, the surface exposed is, in relation to the weight taken, very considerable.

[When the variations in composition are so excessive, analyses of more than one sample are necessary. With reasonable care the weight does not alter so rapidly in making thin shavings as to produce an appreciable error.—L.]

These two sources of inaccuracy are obviated by weighing out for the analysis a section cut through the bar at right angles to its length (60 to 80 grms.), dissolving in distilled water, and making the volume up to 1,000 c. c. (in the cold); 50 c. c. of this solution are measured off for each operation. It should be observed that as some of the alkaline salts of the fatty acids separate out from the solution on cooling, it must be well mixed, by agitation, previously to drawing off each 50 c. c. The several operations are conducted as follows:

1. *Total Alkali.*—50 c. c. of the solution are diluted to about 200 c. c., the liquid is colored faintly with eosine, and standard acid is run in, taking care to stir briskly with a glass rod. The neutral point is extremely well marked by the sudden decoloration of the whole. The cause of this apparent destruction of color is the union of the fatty acids with the eosine at the moment of their complete separation from the fluid.

2. *Uncombined Alkali.*—50 c. c. are added to 300 c. c. of a saturated solution of common salt, which must be, of course, neutral to test paper, and the volume made up to 400 c. c. The neutral alkaline salts of the fatty acids (*i. e.*, true soap) are precipitated; any excess of alkali present remains in solution; this is determined in an aliquot part of the filtered solution; the filter must not be moistened previous to filtration; from this the total uncombined alkali is calculated, and subtracted from the *total alkali* already found. Then the *combined* and *uncombined* alkali are determined.

3. *Fatty Acids.*—50 c. c. of this solution are introduced into a stoppered separating funnel, decomposed with excess of acid and agitated with carbon disulphide until the liberated fatty acids are dissolved. The disulphide solution of the fats is drawn off into a tared flask; the aqueous solution is washed once or twice with small portions of disulphide, the whole of which is then separated from the fats by distillation. The fats are purified from the last traces of CS_2 by heating the flask for a short time at 100° C.; the weight, after cooling, less the tare, gives the weight of the fatty acids. Ordinary ether may be used in place of the CS_2; it has, however, the disadvantage of retaining small quantities of water, and, therefore, aqueous acids, which must be driven off at the end of the operation by exposing to a temperature of 100° to 120° C., until the weight is constant. Further, the ethereal solution will be the upper stratum, and is, for obvious reasons, not so easily to be manipulated as the bisulphide solution, which forms the lower layer.

[The solution of the combined fatty acids in carbon disulphide is unnecessary, since they can be directly determined in the manner detailed further on.—L.]

Note.—A moment's consideration of the following equation, representing the decomposition of sodic oleate by HCl:

$$2\left\{\begin{matrix}C_{18}H_{33}O\\Na\end{matrix}\right.>O+2HCl=2NCl+2\left\{\begin{matrix}C_{18}H_{33}O\\H\end{matrix}\right.>O,$$

will make it evident that while the fatty acid is present in the soap in the form of anhydride, it is separated and weighed in the course of analysis as hydrate. A correction must therefore be applied, based upon the fact that 282 parts oleic hydrate=273 parts oleic anhydride, *i. e.*, the weight of the fatty acids is to be multiplied by the decimal fraction 0·97.

In the case of the "olein" soaps of commerce, a very rapid and tolerably accurate estimation may be made in the following way: 50 c. c. of the solution are decomposed with HCl in a small flask, the neck of which is long and narrow, and graduated in c. c., and so much water added that, upon heating, in the water bath, the separated oil will rise into the neck and fall entirely within the graduated portion. The heating must be continued, with occasional tapping of the flask, until the whole of the fat has been separated and has risen into the neck. The flask is allowed to cool, and when cool the volume of the oil is read off. This quantity, multiplied by the specific gravity of the oil, gives its weight. The specific gravity (which I have almost always found to be 0·9) may be determined by pouring off a small quantity into a capsule (a second reading will give the volume taken), and weighing it; the weight divided by the volume is the required specific gravity.

4. *Water.*—If the purity of the sample has been ascertained, this constituent may be calculated by difference. The direct estimation is effected by evaporating 50 c. c. of the solution to dryness on the water bath (finally in the air bath from 100° to 120° C.) in a weighed dish. The residue is anhydrous soap; from its weight the percentage of water in the soap may readily be calculated. It may be observed that the usual method, which consists in the exposure of the soap, previously cut into thin shavings and weighed, to the temperature of boiling water until it ceases to lose weight, is inaccurate, as it fails to drive off the last portions of water (1 to 2 per cent.), which seem to have contracted a stronger union with the soap.

[This difficulty is not experienced if the soap is dried at 110° to constant weight. See also remarks by author of Method II.—L.]

5. *Mineral impurities and unsaponified fat* may be detected by taking the dried soap from the preceding operation, dissolving in strong alcohol, and filtering through a funnel heated by means of a jacket of hot water. *Mineral impurities* remain upon the filter as an insoluble residue, the weight of which is readily ascertained. The alcoholic filtrate is evaporated with successive additions of distilled water; by these means any unsaponified fat or resin is separated from the soap, which, of course, remains in aqueous solution. This solution may be used for 1, 2, or 3. The mineral impurities may be examined qualitatively after drying and weighing.

[This method of determining the uncombined fat is tedious and troublesome, and furthermore has the disadvantage of not separating the resin from the fat.—L.]

METHOD II.

By C. Hope, in *Chemical News*, xliii., p. 219.

In this paper I intend giving, for the full analysis of soda soaps, a method which I have used for some considerable time, and which I find to be useful in giving information as to how the soap has been made, and also as giving an exact analysis of it, which is much desired by some consumers, and not usually done by analysts. In some cases, a much shorter analysis will suffice, but in a soap-works laboratory the full one will be very often wanted. Before weighing off portions of the soap, I think it is absolutely necessary to cut off the outer skin and take the inside, otherwise discrepancies will result not otherwise to be accounted for. The skin is a very small portion usually of the bar or cake, and it would be a difficult operation to get the proper amount of skin in the different portions weighed.

[As compared with Method I., which necessitates but one weighing of the original sample, this method has the great disadvantage of necessitating no less than seven weighings of the sample, and in quantities varying from 5 to 31 grms. Besides the loss of time thus occasioned, there is a corresponding probability of the various determinations not agreeing among themselves, if the original sample was not uniform.—L.]

Water.—The first thing to be done is to cut some thin shavings of the sample, weighing about 5 grms., and place them in a small tared flat porcelain basin, and the exact weight noted. It is then put in the water-bath and heated until it ceases to lose weight; a night generally suffices for this purpose. When that is done, it is weighed in the morning, and a number of small holes made with a pin in the dried slices, and put in the bath again for a few hours, and reweighed. If there is no further loss, as is generally the case, it is certain the soap is thoroughly dry. Some chemists have condemned this method of estimating the water, because, they say, it fails to give off the last 1 or 2 per cent.; but I find that such is not the case, because when a soap is dried as I have described, it will give no further loss, even if heated to its decomposing point.

Fatty Acids.—A portion of the soap, weighing about 5 grms., in the form of miniature bars, is introduced into a separating funnel of about 120 c. c. capacity, and about 50 c. c. of water at, say, 100° F. poured in, then enough acetic acid to decompose the soap and leave a small excess, and, finally, about 50 c. c. of ordinary ether. The stopper is then put in the funnel, and the whole shaken until the soap is all dissolved. It is then allowed to settle for a few minutes, when the fatty acids will be found to have dissolved in the ether, and floating on the watery solution, which contains the soda salts, etc. The bottom stopper is then opened slightly, and the watery solution of the salts allowed to *drop* slowly out until it stops; then the top stopper is taken out, and the remainder of the water allowed to drop slowly out until only a few drops remain, at which time the stopper is shut. The funnel is then filled up with water about 90° or 100° F., the stopper replaced and shaken for a minute or so, allowed to settle, and the same operation as before repeated. The washing is continued until the washings are neutral, at which point the last few drops are allowed to go out, taking care not to allow any of the ethereal solution to follow it. It is always necessary to open the bottom stopper first, as there is enough ether vapor in the funnel to cause an outward pressure, which, on opening the top stopper, first causes a few small drops of the ether solution to splutter out—a proceeding not to be desired, and which is effectually prevented by operating as described. The dropping of the washings is to be carefully done, otherwise the washings will be found to have a skin of fatty acid floating on the surface, which, of course, would cause a low result, and therefore must be carefully guarded against. The ethereal solution of the fatty acids is then poured out by the top of the funnel into a previously tared beaker of about 150 c. c. capacity, and the funnel rinsed out with fresh ether. The beaker is then covered with filter paper and placed on the top of the water-bath until the ether is evaporated. If the odor still remains in the beaker a few minutes inside the bath, remove it completely. If the water has not been completely removed from the funnel, a few small drops of water will be seen in the fatty acids, and may be removed by the addition of a few drops of absolute alcohol, and then heated inside the water-bath until its odor is gone. The beaker is now cooled and weighed, and, when the tare is deducted, gives the weight of fatty acids in the quantity of soap taken.

[This has the same objections as the extraction with carbon disulphide given in the original plan stated in Method I. See also C. F. C.'s objections to the use of ether instead of carbon disulphide.—L.]

Total Alkali.—For this determination I take 31 grms. of the soap, and put it into a 500 c. c. flask, and dissolve with the aid of heat in hot water. 50 c. c. of standard sulphuric acid are then added, and the flask filled up to the mark; 100 c. c. are filtered off, put into a beaker, and titrated with standard pure caustic soda, using litmus as an indicator. The acid used is a normal one—1 c. c. = 0·062 grm. Na_2O; and the soda used is one-tenth of that strength—1 c. c. = 0·0062. grm. Na_2O.

Sodic Chloride.—To the above neutralized solution, some solution of yellow chromate of potash is added, and then titrated with a decinormal solution of silver, 1 c. c. = 0·00585 grm. NaCl.

Free Alkali.—3·1 grms. of the sample in thin shavings are weighed off and dissolved in rectified alcohol, then filtered as rapidly as possible, and the insoluble matter washed with boiling alcohol. A few drops of alcoholic solution of phenolphthalein are added to the filtrate, and then titrated with the decinormal acid. This gives the free alkali existing as hydrate, usually only a trace or none.

Soda existing as Silicate and Carbonate.—The part insoluble in alcohol is dissolved on the filter with hot water, carbonic acid passed into the filtrate to precipitate a trace of lime usually in it, then thoroughly well boiled and filtered. The filtrate is then titrated with the decinormal acid, using litmus as indicator.

Soda existing as Carbonate.—5 grms. of the soap are dissolved in rectified alcohol, washed as before, and the insoluble dissolved in water. The solution containing the carbonate and silicate is put into a flask fitted with a set of two U tubes containing solution of baric hydrate, and decomposed with dilute acid, and the CO_2 boiled out into the U-tubes. The baric carbonate is filtered off as quickly as possible, the excess of hydrate washed from it, and the precipitate titrated with standard decinormal acid.

Sulphate of Soda.—10 grms. of the soap are dissolved in water, decomposed with HCl, and the fatty acids filtered off. The filtrate is precipitated with $BaCl_2$, and finished in the usual manner.

Silica.—25 or 50 grms. are ignited in a platinum basin, and the residue treated with HCl, evaporated to dryness, retreated with HCl, and the insoluble silica filtered off, ignited and weighed.

Lime, Iron, etc.—The filtrate from the silica is made alkaline with ammonia, some oxalate of ammonia added, the precipitate collected, ignited, and weighed.

Calculation and Statement of Results.—The water, silica, lime, etc., and sodic chloride are simply calculated to per cent. The barium sulphate is calculated to per cent. of sodic sulphate. The alkali soluble in alcohol is calculated to NaHO, and the acid used for titrating the baric carbonate to sodic carbonate. The "soda existing as carbonate" is deducted from the "soda existing as silicate and carbonate," and the difference stated as "soda existing as silicate." The silica cannot be stated as silicate of soda, because the "silicate" as used, and as it exists in the soaps, is not a normal one. It has an approximate composition of $Na_2O_4SiO_2$, but it is evidently not a definite compound; so that, under those circumstances, it is necessary to state the silica as such, and give the soda existing with it. It was pointed out by a writer in the *Chemical News* some years ago, and seems to be still ignored, that, although in the process of analysis the fat is separated and weighed as fatty acid, it exists in the soap as fatty anhydride, as the following reaction, representing the decomposition of sodic oleate by an acid, shows:

$$2\left\{\begin{matrix}C_{18}H_{33}O\\Na\end{matrix}\right\}O+2HCl=2NaCl+2\left\{\begin{matrix}C_{18}H_{33}O\\H\end{matrix}\right\}O,$$

and that by multiplying the fatty acids by the factor 97,

the true weight of fatty matter existing in the soap was found. If the fatty acids are stated in the analysis, it will be found the analysis will total to nearly 102; therefore, because the per cent. of fatty acids are usually wanted, I generally report the analysis in the following manner:

	Per cent
* Fatty anhydride	
Soda existing as soap	
Water	
Sodic carbonate	
" hydrate	
" chloride	
" sulphate	
Silica	
Soda existing as silicate	
Lime, etc.	

There are two other important points in connection with soap analysis, viz.: the determination of the resin, and the melting-point of the fatty acids, that I intended to speak of in this paper, but I have not been able to get the experiments finished, so that I must leave them for a future communication to the section. A method for the accurate determination of resin in soap, whether easy of execution or otherwise, is a thing still wanted. I have been working lately at a method which, although not a quick one, promised well for accuracy, and which I now find to give results short of the truth, because of the different resinic acids in resin having different solubilities in certain reagents.

METHOD III.

Cairn's Manual of Quantitative Analysis, p. 244, somewhat modified.

Water.—Dissolve 1 to 2 grms. in the smallest possible amount of strong alcohol, pour the solution upon sand in a dish, the sum of whose weight and that of the sand has already been determined, and dry in air bath at 110° C., to constant weight.

[The objections to this method are that the weight taken is so small that it may not represent a fair average. It is difficult to transfer a strong alcoholic solution without considerable washing, and so increasing the volume of the alcohol to be evaporated. Great care is requisite in evaporating the solution not to lose by spirting, even when the evaporation is conducted on a water bath heated with a very small flame. The sand as well as the soap is hygroscopic, and even if, after ignition, the sand is allowed to cool to 110° in an air bath before being transferred to a desiccator previous to weighing, the results are not accurate. It is not unusual to state as part of a soap analysis, "water by difference," but in this case the direct determination of the water should be given also.—L.]

Solution.—Dissolve 5 grms. of the soap in 100 c. c of 90 p. c. alcohol by warming on water bath to 40° to 50° C.—Filter through a weighed filter paper—(A.) Filtrate. (B.) Residue on filter.

(A.) Filtrate. Precipitate the uncombined alkali as bicarbonate ($NaHCO_3$) by passing a slow stream of well-washed carbonic acid through the filtrate. Allow the well-covered beaker glass to stand until the liquid is clear, warm on the water bath, filter, and wash with warm alcohol. Dissolve the precipitate in water, titrate with normal sulphuric acid, and calculate to NaHO for *uncombined alkali*.

Combined Fatty Acids.—Transfer the filtrate or the alcoholic solution in which CO_2 failed to produce a precipitate to a flask, add 100 c. c. water, and evaporate or preferably distill off the alcohol. Add 15 c. c. of normal sulphuric acid and 5 grms. pure white wax, boil, filter through a wetted filter, and wash with boiling water until the washings are no longer acid. After pressing and drying between filter papers, the weight of the cake, less the weight of wax added, is the sum of the weights of the combined fatty acids, uncombined fat, and resin.

[I failed in attempting to carry out these directions. The soap and wax were almost entirely in one large cake, but some was left after boiling on the sides of the beaker, and could not be removed by mechanical means. The use of solvents was likewise attended with difficulties and objections. By heating at 100°, however, until every trace of water was driven off and the weight became constant, and deducting the weight of the beaker, a result was obtained nearly identical with that found by Method IV.—L.]

Combined Alkali.—Titrate by normal soda solution the filtrate from the wax in order to find how much of the sulphuric acid has been neutralized by the combined alkali of the soap. Calculate to Na_2O.

(B.) *Residue.*—Wash the residue on filter with hot alcohol, dry at 110°, and weigh. Wash with water, dry at 110°, and weigh. The last weighing gives the *insoluble residue*. The wash water which contains the free carbonate is titrated with sulphuric acid, and the result calculated to Na_2CO_3.

Uncombined Fat.—Treat 5 grms. of the soap (cut into very fine shavings) with ether two or three times, pouring off the ether into a weighed dish. The operation may be assisted by placing the vessel over a water bath containing hot water, but with no flame under it. Since the ether may dissolve small portions of the soap, it is safer to evaporate off the ether from the first extraction, and then to treat the residue again with ether. The weight of the residue left on the last evaporation of the ether gives (2) uncombined fat. Carbon disulphide may be used in place of ether.

[Complete and satisfactory extraction with ether is troublesome to effect in an open dish.—L.]

Resin.—Dissolve 40 grms. of the soap in boiling water, add an excess of sulphuric acid to separate the fatty acids and resin; cool, pour off the aqueous portion, and digest the fatty residue with equal volumes of alcohol and water, agitating from time to time. Pour off the milky fluid, add more alcohol and water, and digest again. Repeat this until the fluid ceases to become milky, then add water and a weighed quantity of wax as before, filter, dry, and weigh the cake. The weight represents that of the fatty acids deprived of the resin. The difference of percentage obtained in this way from the percentage obtained as above described gives approximately the amount of the resin present.

[This method is very difficult of execution and gives only approximate results.—L.]

Glycerine.—Dissolve 5 grms. of the soap in 90 per cent. alcohol, add dilute alcoholic sulphuric acid (1 vol. sulphuric acid to 10 vols. alcohol) so long as a precipitate forms, wash with alcohol, digest with barium carbonate and alcohol until the alcohol is gone, filter, evaporate the filtrate to dryness in a weighed dish, and weigh the residue of glycerine.

[This residue should be entirely soluble in water, and should be carefully tested to see whether, as is probably not the case, it is pure glycerine.—L.]

Mineral Constituents.—Calcine 5 grms., dissolve in water, filter, wash, dry at 110°, and weigh the *insoluble residue*. Dilute to 100 c. c. In 25 c. c. determine *total alkali* by titration with half-normal sulphuric acid. In another 25 c. c., determine *chloride* by titration with standard silver nitrate, using potassium chromate as indicator. In a third 25 c. c. determine *sulphate* with barium chloride. In the last 25 c. c. determine *silicic acid* by evaporation to dryness with hydrochloric acid.

[This makes the sixth separate weighing of different portions of the sample, and contemplates the determination of two previously determined constituents. By ignition with so much organic matter, any sulphate present is partly reduced to sulphide.—L.]

METHOD IV.

By Julius Loewe, Fresenius' *Zeitschrift*, xix., p. 112.

Water.—8 to 10 grms. of the soap in fine shavings is heated first at 60° to 70°, then at 100° to 105° to constant weight. In order to prevent absorption of CO_2 by the free alkali, the desiccation should be performed in an atmosphere free from CO_2.

Uncombined Fat.—The thoroughly dried soap which has been used in the water determination is treated two or three times with warm benzol or petroleum ether, in a tall covered beaker. After each treatment the liquid is allowed to stand until clear, and decanted into a tared flask. If the liquid cannot be safely decanted, it is filtered through a weighed filter, which is afterward employed for the alcoholic solution of the soap. The filtrates are finally distilled, and the weight of the residue in the flask, after drying at 110°, gives the uncombined fat.

The residue from the uncombined fat is treated with 8 to 10 times its weight of 90 per cent. alcohol, and warmed on water bath to 40° to 50°. The fatty acids along with the caustic alkali and glycerine are dissolved, while soda carbonate, potato starch, and mineral matters remain undissolved, and after washing with hot alcohol and drying at 100°, are weighed. In the better soaps for household use, only a residue of 1 to 1·5 p. c at the highest, and consisting mostly of soda carbonate, should remain.

Examination of this Residue—Starch Meal and Mineral Constituents.—Wash with cold water until the filtrate amounts to exactly 60 c. c. Wash the filter and precipitate with alcohol until it has taken the place of the alcohol, dry at 100°, and weigh. The weight gives the amount of insoluble organic matters, like starch, etc. (which should be further examined under the microscope), and insoluble mineral matters.

In 15 c. c. of the 60 c. c. filtrate determine the quantity of carbonic acid set free by acid, and calculate therefrom the quantity of soda carbonate.

[This method of estimation is less convenient than that by titration, as before given, and no more accurate.—L.]

In another 15 c. c. determine the chloride, and in another the silicate.

Uncombined Alkali.—The filtrate from the above residue is treated with CO_2, the beaker well covered is allowed to stand on a water bath until the supernatant liquid has become clear, and the precipitate of carbonate is filtered and washed with warm alcohol.

Combined Alkali.—The alcoholic filtrate is treated with alcoholic sulphuric acid (1:10) as long as precipitation occurs; after standing, the precipitated sodium sulphate is filtered off, collected on a weighed filter, washed with alcohol, dried at 110°, and weighed. From this weight is calculated that of the combined alkali.

Combined Fatty Acids.—To the filtrate acidified with sulphuric acid, water is added in a platinum dish, and the alcohol expelled by heating. After cooling, the fatty acids are separated by filtration.

Glycerine.—The filtrate is treated with barium carbonate to remove the excess of sulphuric acid, and contains the glycerine.

A NEW SCHEME FOR THE ANALYSIS OF SOAP.

By the Author. (*See Table.*)

(1) *Water.*—Weigh out about 5 grms. in very fine, small shavings upon a dried, weighed, plated filter. Dry at 110° until weight is constant. The loss is water.

(2) *Uncombined fat.*—Transfer the filter, containing the dried soap, to the funnel connected with the return cooler, such as is used in the determination of the albuminoids in milk, and connect with the funnel a small tared flask containing 50 c.c. petroleum ether. After complete extraction distill off the ether, and the residue in the flask, dried at 110°, will be the uncombined fat.

(3) *Soap*; (4) *free alkali*; (5) *glycerine.*—Allowing the funnel, with the soap freed from moisture and from fat, to remain on the return cooler, attach to it a flask containing about 75 c. c. of 95 per cent. alcohol and extract. To the alcoholic solution add a few drops of phenol-phthalein; if free acid be present, neutralize with normal sulphuric acid, and calculate the amount of uncombined soda.

After neutralization add a large excess of water and boil off the alcohol. To the aqueous solution add a large excess of normal sulphuric acid. Boil, cool, and decant through a small filter, wash with hot water and decant, after cooling, through the filter, until litmus paper is no longer reddened by the washings. The filtrate consists of the combined

DR. LEEDS' SCHEME FOR SOAP ANALYSIS.

<table>
<tr><td colspan="11">Weigh out 5 grms. Dry at 110°. Loss corresponds to water.</td></tr>
<tr><td colspan="11">Treat with petroleum ether.</td></tr>
<tr><td rowspan="5">Extract is uncombined fat. Dry at 110° and weigh.</td><td colspan="10">Residue is soap and mineral constituents. Treat with alcohol.</td></tr>
<tr><td colspan="5">Extract is soap (fatty anhydride, resin, and combined alkali), glycerine, and free alkali. Add two or three drops of phenol-phthalein. If necessary, titrate with normal sulphuric acid.</td><td colspan="5">Residue.—Na_2CO_3, NaCl, Na_2SO_4, sodium silicate, starch, and insoluble residue. Wash with 60 c.c. water.</td></tr>
<tr><td rowspan="3">H_2SO_4 used corresponds to free alkali. Calculate as NaHO</td><td colspan="4">Add a large excess of water and boil off the alcohol. Decompose with excess of normal H_2SO_4. Boil, filter, and wash.</td><td colspan="4">Filtrate.—Na_2CO_3, NaCl, Na_2CO_4, and sodium silicate. Divide into four equal parts.</td><td rowspan="3">Residue.—Starch and insoluble residue. Dry the filter and weigh. The weight is the starch and insoluble residue. Starch.—Convert the starch into $C_6H_{12}O_6$. Titrate with Fehling's solution. Subtract the weight of starch found and the difference is the insoluble mineral constituents.</td></tr>
<tr><td colspan="2">Filtrate.—Combined soda and glycerine. Titrate with normal soda solution.</td><td colspan="2">Residue—Fatty acids and resin. Dry at 110° and weigh. Dissolve an aliquot part in 20 c.c. strong alcohol, and, using phenol-phthalein as an indicator, saponify with soda in slight excess. Boil, cool, and add ether to 100 c.c. Decompose with $AgNO_3$ by adding in fine powder, and shake well for ten minutes. Allow to settle.</td><td rowspan="2">Na_2CO_3. Titrate with normal H_2SO_4, and calculate as Na_2CO_3.</td><td rowspan="2">NaCl. Titrate with $AgNO_3$ or weigh as AgCl. Calculate as NaCl.</td><td rowspan="2">Na_2SO_4. Weigh as $BaSO_4$. Calculate to Na_2SO_4.</td><td rowspan="2">Sodium silicate. Decompose with HCl and determine soda combined in silicate and silica.</td></tr>
<tr><td>H_2SO_4 used corresponds to combined soda in soap. Calculate as Na_2O.</td><td>After titration evaporate to dryness on the water-bath. Treat with absolute alcohol. Evaporate the alcoholic solution to dryness in a tared dish and weigh as glycerine.</td><td>Precipitate is Stearate, Palmitate, and Oleate of Silver.</td><td>Solution.—Resinate of silver. Filter 50 c c. from the total 100 c c. Decompose with 20 c c. HCl (1 : 2). Allow the AgCl to settle, and evaporate an aliquot part of the ethereal solution in a tared dish. Dry at 110° and weigh. After applying collection for oleic acid, the weight corresponds to the resin. This weight subtracted from the combined weight of fatty acid and resin gives the fatty acids.</td></tr>
</table>

* = Per cent. fatty acids. Per cent. total soda.

soda and glycerine, the residue of the fatty acids and resin.

Neutralize the filtrate with normal soda solution and calculate the amount of combined soda as Na_2O. Evaporate to dryness, and extract the glycerine with absolute alcohol. Transfer the alcoholic solution to a tared flask, distill off the alcohol, dry at 100°, and weigh the residue as glycerine.

Fatty acids and resin.—Dissolve the small amount of the fatty acids and resin that may be on the filter, through which the decantation was effected, with a little petroleum ether, add the solution to the larger bulk in the beaker, evaporate off the ether, dry at 110°, and weigh the combined fatty acids. Multiply this result, after subtracting the amount of the resin, by 0·97, and the product is the fatty anhydrides.

(6) *Resin.*—The resin was separated from the fatty acids according to the method proposed by Gladding (*Amer. Chem. Jour.*, vol. iii., p. 416). About 0·5 grm. of the mixture of the fatty acids and resin are dissolved in 20 c. c. of strong alcohol, and with phenol-phthalein as an indicator, soda is run in to a slight supersaturation. The alcoholic solution, after boiling for ten minutes to insure complete saponification, is mixed with ether in a graduated cylinder till the volume is 100 c. c. To the alcoholic and ethereal solution 1 grm. of very finely powdered $AgNO_3$ is added, and the contents of the cylinder are shaken thoroughly for ten or fifteen minutes. After the precipitate has settled, 50 c. c. are measured off, and if necessary, filtered into a second graduated cylinder. A little more $AgNO_3$ is added to see if the precipitation is complete, and then 20 c. c. of dilute hydrochloric (1:2) to decompose the silver resinate. An aliquot part of the ethereal solution in the cylinder is evaporated in a tared dish, and weighed as resin, deducting a small correction (for 10 c. c. deduct 0·00235 grm.) for oleic acid. The amount of resin subtracted from the combined weight of fatty acids and resins, as found before, gives the fatty acids.

(7) *Sodic carbonate*; (8) *sodic chloride*; (9) *sodic sulphate*; (10) *sodic silicate*; (11) *insoluble residue.*—The filter in the funnel connected with the return cooler, after treatment with alcohol, contains the mineral constituents of the soap. The contents of the filter are washed with cold water till the washings amount to 60 c. c. The filter is then dried and weighed. The weight gives the insoluble residue and starch.

The starch is converted into $C_6H_{12}O_6$ with dilute acid, and titrated with Fehling's solution. The weight of starch found, subtracted from the total weight of insoluble residue and starch, gives the insoluble mineral constituents.

The aqueous solution of 60 c. c., just mentioned, is divided into four equal parts, in one of which is determined the carbonate of soda, by titration, and in the other parts the chloride, the sulphate, and the silicate respectively, by any convenient method.

ARTIFICIAL PRODUCTION OF ELEMENTARY ORGANIC FORMS.

SOME interesting experiments upon the preparation of artificial cells, made by Monnier and Vogt, have been described in the *Journal de l'Anatomie et de la Physiologie*.

The starting point for these investigations was some observations made a few years ago by Monnier. Having dropped a piece of zinc sulphate into a solution of saccharate of lime, he noticed, under the microscope, that tubes were formed which spread out and grew in all directions. They were bounded by real walls, which were very thin in the smaller tubes, but in the larger ones they had a double *contour* and a perceptible thickness. These tubes grew in length beneath the eye of the observer; they contained fine granulations, which began to form at the open end of the tube, and extended along the walls. Finally, the phenomenon ended with the tube closing in a point.

For the success of this fundamental experiment, Monnier and Vogt direct that a solution of saccharate of lime be prepared of such consistence that it is but slightly sticky. One drop of the liquid is placed on a glass slide, and then a little dust is scraped from a crystal of copper sulphate with the handle of the scalpel and strewed over the liquid. On looking through the microscope, a beautiful formation of tubes is seen.

In their subsequent experiments, the authors sought to obtain the same phenomena with entirely inorganic bodies. Believing that the tenacity of the liquid was very essential, they chose a solution of sodium silicate of suitable concentration, on which they placed some crystalline powder of copper sulphate, as well as other sulphates, such as iron, nickel, zinc, and magnesia. All the sulphates formed tubes with the sodium silicate (water-glass), which were absolutely identical in form with those obtained from the saccharate.

At the instant when the tiny crystal of sulphate falls into the liquid it becomes surrounded with a transparent film (skin), which is unusually dialytic, and through which the liquid continues to act. The crystal is seen to decrease, while the membrane expands and increases. This membrane permits nothing but the liquid to pass through it; for, if the sodium silicate is colored with finely powdered carmine, it will be found that this neither penetrates into the original cell nor into the advancing tube. After the envelope of this decomposing scrap of a crystal has been distended, it gives out tubes in every direction.

The forms of these tubes are constant for every sulphate. Their thickness depends, for the greater part, on the size of the piece of crystal put into the liquid, the larger pieces producing wider tubes. On the tubes there may be observed ramifications, scars, cross sections, and within a semi-fluid, transparent substance, in which are some very minute granules. These latter sometimes form undulating streaks in the thick tubes; in others, they collect behind the cross walls. Most frequently they lie along the sides, leaving the center of the round tube (they are always round) perfectly transparent. Such artificial tubes have been noticed, which were easily mistakable for thick, nervous fibers with cylindrical axes and granular myelæ.

The tubes formed by zinc sulphate were colorless, but the other sulphates were more or less green. All these tubes, formed in the silicate, are very strong, and, after washing with distilled water, can be preserved under water, and exhibited as preparations. If these tubes are dried, they cannot be distinguished from the needles of certain sponges.

[A very handsome experiment may be performed by filling a glass cylinder, ten or twelve inches high, with a dilute solution of sodium silicate (1 of commercial water-glass solution to 4 of water), and dropping in a few crystals of iron sulphate as large as peas. In half an hour threads or tubes will be seen ascending from the crystals; and by the next day they will be six or eight inches long, and of a rich green color. Copper sulphate forms blue tubes; manganese sulphate, pink; and the zinc salt, white.—ED.]

The principal condition required of the liquid in which these forms, resembling organic cells, are produced is slight tenacity; hence other inorganic substances were used instead of the silicate for these experiments—such as alkaline carbonates and calcium sulphate. No tubes were formed in the alkaline carbonates (potassium, sodium, and ammonium), but only round cells, with open pores. The cells were, however, as firm as the tubes. They had walls of greater or less thickness, and in most cases there was in the center of the cells a little heap of undecomposed grains of the salt, giving them the appearance of a nucleus. From this center canal pores radiated toward the periphery, sometimes thicker, and at others thinner, in wavy or serpentine lines; frequently straight, like the radii of a sphere; at other times thick in one place and thin in another. All these little canals reached to the periphery, where they were wide open. With a suitable arrangement of the microscope, a stream of granules could be seen issuing forth from the canal and proceeding further; but this was soon checked, and then the walls of the cell formed a limit to their movements.

All the carbonates examined formed cells, while the sulphates sent forth tubes. Nevertheless, there are exceptions, so that the sulphates of nickel and of magnesia yielded mixed forms with the sodium silicate.

The experiments thus briefly sketched will be more fully described in a longer essay. Monnier and Vogt draw the following conclusions from these experiments:

1. Any two salts, which by mutual reaction upon each other are able to produce one or two insoluble compounds, may, by acting in a suitable (tenacious) liquid, produce forms that have all the characteristics of the elementary organic (or organized) forms, such as simple cells with canal pores, tubes with side walls, cross walls, heterogeneous granular contents, etc. To produce these artificial cells and tubes, one of the salts must be dissolved in the liquid, while the other (although soluble) must be present in a solid state.

2. These elementary organic forms (cells and tubes) can be produced as well in liquids of organic, or semi-organic origin (*e. g.*, saccharate of lime), as in one entirely inorganic (like sodium silicate). Henceforth, there will no longer be any discussion regarding the distinguishing forms that characterize inorganic substances on one side, and organic bodies on the other hand.

3. The production of these pseudo-organic forms depends on the liquid in which it is to take place on its concentration and sticky or adhesive character; but in many tenacious liquids, like solutions of gum arabic and of zinc chloride, they are never formed.

4. The shape of these pseudo organic elements is constant for the same crystallized salt, and just as constant as any crystalline form of a mineral. These forms are so characteristic that they can serve to identify or detect a very small quantity of a substance in mixtures. They can be utilized as a delicate analytical test, like spectral analysis, for example, to distinguish the carbonates, sesquicarbonates, and bicarbonates from each other. [This last sentence does not seem justified by the facts given.]

5. The shape of these artificial, pseudo-organic elements depends chiefly on the acid in the solid salt employed. The sulphates, and in certain cases the phosphates, produce, as a rule, tubes, while the carbonates form cells.

6. Aside from the few exceptions, like the sulphates of copper, cadmium, zinc, and nickel, these pseudo-organic forms are only produced by the mutual reaction of substances that actually occur in organized substances. Saccharate of lime, for example, yields these organic forms, while saccharate of barium and strontium yield none.

7. The artificial, pseudo-organic elements are surrounded by actual membranes of great dialyzing power, which only permit liquids to pass through. Their contents are heterogeneous, and within are formed granules that are arranged in a definite manner. They are, therefore, both in constitution and form, absolutely similar to the elements from which organisms are built up.

8. It is probable that the inorganic elements which are found in the organic protoplasma play an important part in the constitution of the organized organic elements in determining the shape which they shall assume.—*Naturforscher.*

A PHOSPHORESCENT TABLET AS A STANDARD LIGHT.

By ARNOLD SPILLER.

MR. BRIGHTMAN'S communication to the Bristol Photographic Society, on "The Effects of Temperature on Sulphide of Calcium," suggested to me that it would be interesting to determine the varying amount of light radiated at different temperatures by a phosphorescing surface. For the purpose of making the determination, one side of a flat tin vessel was coated with luminous paint, so that by pouring water of the requisite temperature into the tin, and inserting a thermometer, the temperature of the luminous surface might easily be ascertained. To measure the light a gelatino-bromide film was placed behind a sensitometer, consisting of different thicknesses of gelatine varying from one to twenty-five. The following was the mode of working: The tin was first filled with a freezing mixture consisting of ammonium chloride, potassium nitrate, and water, and when the thermometer registered 0° C., the painted surface, after being wiped dry from the condensed moisture, was insolated by burning one inch of magnesium ribbon near to it. After one minute had elapsed from the time of insolation, the sensitometer containing the gelatino-bromide film was exposed for half a minute against the phosphorescent surface. The experiment was thus repeated nine times, the freezing mixture being replaced by water varying from 10° to 80° C., and after the exposures had been made, all the gelatino-bromide films were placed in the same developer. On examination after development, the gelatine films all showed the same shade on the sensitometer, proving that the same amount of light was radiated whether the luminous surface be at 0° C. or 80° C. At the time I was much puzzled to account for this result, for it is a well-known fact that when a phosphorescing tablet is heated, the light increases in brilliancy *pro tem.* However, on reconsidering the matter, I discovered that there was one difference between my experiment and that of Mr. Brightman; for while the latter experiment heated the luminous surface after insolation, I heated the phosphorescent tablet to the required temperature *previous* to insolation.

To confirm my previous result, I coated four glass test tubes externally with the phosphorescent paint; into one tube was placed hot water, and into another a freezing mixture; all four tubes were then exposed simultaneously to the light of burning magnesium. On examination, after the lapse of a few seconds, it was found that the tube containing the freezing mixture gave out as much light as that which was treated with hot water; then, into the two empty but luminous tubes were placed hot water and freezing mixtures, respectively, with the result that, while the heated surface increased in brilliancy, the cool surface slightly decreased. This conclusively proved that the one (apparently trivial) variation in the mode of conducting the experiments made all the difference in the result.

Having discovered this fact, I set about to account for it; but at first was unable to do so, until, after repeating the last described experiment, I observed the tubes half an hour or so after the insolation, and found that while the two tubes containing the cooling mixture were still phosphorescing, those which contained the hot water were almost non-luminous. This result at once accounted for the phenomenon, and proved that *a phosphorescent surface is capable of absorbing varying amounts of light at different temperatures; the lower the temperature, the greater the amount of absorption.**

The above experiments also prove, in opposition to Mr. Brightman's statement, that a phosphorescent plate may be used as a standard light, provided that the exposure be made within a few minutes of insolation, and the temperature of the tablet remains constant between insolation and exposure.†

After making the above experiments, I find that Mr. Warnerke has already noticed the same phenomenon; but on describing my results to several photographers, they have all expressed their opinion that the phenomenon is not generally known, and therefore I venture to think no apology is needed for republishing experiments which, although not new, appear to have been overlooked by some photographers who are in the habit of using the Warnerke sensitometer; and this communication may help to reinstate it in public estimation against the rumor that it is "utterly unreliable."—*Photographic News.*

SOME OF THE DANGEROUS PROPERTIES OF DUSTS.‡

By F. A. ABEL, C.B., F.R.S., President of the Institute of Chemistry.

WHEN dealing with the subject of so-called accidental explosions, in a discourse delivered to the members of the Royal Institution, in March, 1875, the lecturer pointed out that combustible, and especially inflammable substances, if sufficiently light and finely divided to allow of their remaining for some time suspended in air in considerable quantity, so as to form an intimate mixture with it, may, when ignited in this condition, produce explosive effects. The combustion of the finely divided particles, which, under such conditions, are first inflamed, at once communicate flame to those in their immediate vicinity, and combustion is thus transmitted by and through the surrounding mixture of dust and air with a rapidity regulated by the inflammability of the dust, and by the proportion and state of division in which it is distributed through the air. If a rapidly burning mixture of this kind is confined, its combustion will be attended by explosive effects, the degree of violence of which is determined by the combustibility of the dust, by the quantity of mixture ignited, and the nature of its confinement. Its behavior is indeed quite similar to that of a mixture of inflammable gas or vapor and of air; at the instant of its ignition each dust particle is to a more or less considerable extent converted into inflammable vapor, or is, at any rate, surrounded by an envelope of burning vapor, so that if the particles are in sufficiently close proximity to each other, the rapidly successive development of vapor from them as the flame spreads gives rise to a condition of things very like that which obtains when an inflammable gas, or vapor, originally existing as such, is mixed with air.

Even the most inflammable solid, in the form of dust, must be mixed in large proportion with air, must, indeed, be present in the form of a dense cloud, in order that the transmission of flame may proceed continuously from the portion first ignited to surrounding parts of the mixture. A dense cloud of lycopodium dust in air will transmit flame with rapidity and violence throughout its whole extent, but if the particles in the cloud be not in very close proximity, the application of flame to it will only produce short flashes in the vicinity of the source of flame, and the fire will not spread to surrounding particles.

The difficulty of maintaining, if only for a brief period, a sufficiently uniform and highly charged mixture of air with even a very light inflammable powder, to insure the propagation of flame through it, and the circumstance that, with powders which are not very highly and completely inflammable, only some portion of the combustible matter is actually burned when flame is applied to the mixture of dust and air, necessitate the presence of a proportion of dust more or less considerably exceeding that which is proportionate to the oxygen supply in the volume of air with which it is mixed, if flame is to be transmitted by the mixture.

This condition is not difficult of fulfillment in practical operations in which inflammable dust is dealt with, and flame may consequently be transmitted upon a large scale through mixtures of inflammable dusts and air, with a rapidity calculated to produce more or less violently explosive effects, as has been demonstrated by many accidents in works where manufacturing operations have been attended by the production and escape into the air of large quantities of inflammable dust. The accidental inflammation of sulphur dust in chambers in which its pulverization has been carried on has given rise to more than one considerable and somewhat violent explosion. Cotton mills have been known to become rapidly fired by the ignition of, and transmission of flame by, mixtures of cotton dust and air, and very quickly spreading conflagrations originating from dust explosions have occurred in other works dealing with even less inflammable and dust producing materials; thus, at the Garancine Mills, at Sorgues, an explosion occurred in 1878, consequent upon the ignition of a mixture of air with the dust of that substance. But the most numerous and extensive calamities connected with the accidental ignition of mixtures of light inflammable dust and air have occurred in flour and rice mills.

The cause of many disastrous explosions and fires which occurred in flour mills at Budapesth, in Hungary, at Fridest, in Germany, in other parts of the Continent, and in England, prior to 1872, appeared enveloped in much mystery, until

* This phenomenon is analogous to the solution of gases in water, for the colder the water, the greater the amount of gas dissolved.

† In the instructions issued with the Warnerke sensitometer, it is especially pointed out that the phosphorescent tablet must not be touched with warm fingers after insolation.

‡ A lecture delivered at the Royal Institution of Great Britain, Friday April 28, 1882.

Dr. Watson Smith directed attention to the fact that an Austrian observer had apparently traced their origin to the ignition, by flame or some incandescent body (such as sparks produced by the millstones), of mixtures of air and the dust of meal and husks formed during the grinding of corn or subsequent treatment of flour. The occurrence of a very serious explosion and fire at the Tradeston Flour Mills, in Glasgow, in January, 1872, caused that gentleman to direct public attention to what appeared the true explanation of these disasters, and on the occasion of that catastrophe, when several persons were killed and a number injured, the subject was carefully investigated by Messrs. Rankin and Macadam. The origin of the explosion was conclusively traced to the striking of fire by a pair of millstones, through the stopping of the feed, and the consequent friction of their bare surfaces against each other; the results being the ignition of the mixture of air and fine flour dust by which the millstones were surrounded, and the rapid communication of flame thereby to the mixture of dust and air which filled the conduits in communication with the exhaust box: this being the common receptacle into which the mixture of dust and air is drawn, by an exhaust fan, through the conduits communicating with the several mills. From the exhaust box, where a portion of the suspended flour dust was deposited, the air, still laden with dust, passed, in the Tradeston as in other flour mills, to another chamber, called the stive room, where a further quantity of the flour dust would deposit. A connected series of channels and larger inclosed spaces was therefore filled with a dust laden atmosphere, through which flame was so rapidly transmitted from the millstones where the first ignition occurred as to produce violent explosive effects, which succeeded each other with very great rapidity in different parts of the building. The production of the blaze at the millstones was observed to be immediately succeeded by a crackling noise as the flame rapidly spread through the conduits to the exhaust box upon an upper floor, whence a loud report almost at once proceeded.

Messrs. Rankin and Macadam's inquiries elicited the facts that other flour mill explosions had been attended by a similar succession of effects to those above indicated, and that at the Tradeston Mills themselves a less violent explosion, resulting in the bursting open of an exhaust box, attended by injury to some workmen, and the blowing out of windows and loosening of tiles, had taken place on a previous occasion. In the later accident, the more violent explosion of the exhaust box was followed by other distinct explosions in distant parts of those extensive mills, to which fire was led by the dust laden air existing in the many channels of communication, and in which the cleansing and sifting operations, all attended by the escape of dust, were carried on.

Messrs. Rankin and Macadam ascertained that accidents of this nature at flour mills were of frequent occurrence, especially since the exhaust arrangements had been applied to the larger flour mills, and in their report they point out that it seems scarcely possible to guard against such accidents, though their frequency may be reduced by adopting efficient precautions for avoiding the stoppage of the feed to the millstones and the access of nails or other iron particles to the stones; and by prohibiting the employment of naked lights in the vicinity of the mills or dust passages. They also suggest that measures should be taken to reduce, as far as possible, the violence of explosions and the risk of injury to life and property, by constructing all receptacles into which the dust laden air is drawn or passed from the mills, etc., as lightly as possible, so as to offer little resistance to the sudden expansion due to the ignition of an inflammable mixture, and by placing such receptacles as the exhaust box and stive room outside the building.

Since the publication of Messrs. Rankin and Macadam's valuable report, the accidents at flour mills appear, however, to have been scarcely less numerous or disastrous than before the date of the Tradeston catastrophe. Thus, in September, 1874, a similar, though less serious, explosion occurred at the Port Dundas City Mills; and in May, 1878, another flour mill explosion, quite unparalleled for its destructive effects, occurred at Minneapolis, Minnesota, where eighteen lives were lost and six distinct corn mills were destroyed. Mr. Peckham, writing after the event from the university at Minneapolis, states that two dull explosions rapidly succeeding each other were heard by him, and on looking toward the manufacturing part of the city a large volume of black smoke was seen to envelop the spot where the Washburn A Mill stood, a column of smoke being at the same time projected to a height of several hundred feet. A storm was blowing at the time in the direction from the Washburn Mill to other mills in the neighborhood, and in about five minutes from the time that the explosion was heard five neighboring mills, with adjoining premises, were in flames. Persons who were in close vicinity to the scene of the calamity at the time of the first explosion heard a succession of sharp hissing sounds, doubtless caused by the very rapid spread of flame through the dust laden air in the passages leading from the mills to the exhaust box, and, at the instant of the explosion, the Washburn A Mill was observed to be brilliantly illuminated from top to bottom. The nearest mill to the latter was 25 feet distant, and appears to have exploded directly the flames burst through the first mill. The explosion of a third, 25 feet distant from the second, followed almost immediately; and the other three mills, about 150 feet distant in another direction, were at once fired. Windows were thrown out of buildings about a quarter of a mile distant, consequent upon the back rush of air following the explosion, and portions of the building materials were projected to very considerable distances. The cause of the explosion was carefully inquired into (by Messrs. Pick, Peckham, etc.), and it was attributed to fire being generated by the stoppage of the feed to a pair of stones, or by the accidental passage of some very hard substance between them. The consequent explosion of dust and air mixture round the stones and in the communicating passages added, by its concussion, to the quantity of dust suspended in the air in different parts of the mill, and a second more violent explosion was thus immediately brought about. The attention of Professor Lawrence Smith was directed to the subject of flour mill explosions by this accident, and in a letter to M. Dumas, of May 4, 1878, which was published in the *Annales de Chimie et de Physique*, he states his conviction, based upon experimental inquiry, that such accidents are due to the formation of explosive mixtures of finely divided organic matters (such as flour) with the air, and refers to this as a "revelation" of the existence of a previously unknown danger connected with an important industry, being apparently unaware of its elucidation by Rankin & Macadam, and Watson Smith in 1872.

Attention has again been recently directed to this subject of flour dust explosions by a fatal and extensive calamity of the kind which occurred at a flour mill at Macclesfield in September, 1881, and has been made the subject of an interesting report to the Home Secretary by Mr. T. J. Richards, of the Board of Trade, in which he confirms the conclusions of Messrs. Rankin and Macadam, and repeats the recommendations made by them.

In this particular case, again, there appears to have been no doubt that the inflammation of the dust and air mixture surrounding a particular pair of millstones was due to the stones remaining empty for some time, sufficient heat being consequently developed to ignite some portions of flour dust existing between the bearing surfaces. One of the owners of this mill deposed that he had seen flame produced by stones when remaining empty, and that the appearance of the stones in question convinced him that flame had been thus produced. A very dry grain was, moreover, being ground at the time of the explosion. A strong consensus of opinion appears to exist that it is very difficult, with the best arrangements for feeding the millstones with grain, to guard against their running empty occasionally, and there is no doubt that on these occasions portions of flour are exposed to heat sufficiently great to char and sometimes even to ignite them. In connection with this effect of the heat, to which portions of flour may be exposed between "dry" stones, the opinion of an "experienced person" (quoted as a regrettable one by Mr. Richards) deserves not to be lost sight of. It is to the effect that a stive room can at all times be safely entered with a naked light "except when there is observed the peculiar odor which is noticed there when one of the millstones has been previously running empty." It is not difficult to demonstrate that fine flour *very* thickly suspended in air will produce with the latter an inflammable mixture, through which flame will be rapidly transmitted; there is also no doubt that if, as is frequently the case, the inclosed dust and air mixture in the air passages of a mill is somewhat warm, the propagation of flame through the mixture will be facilitated. But experimental observations, which the lecturer has had occasion to make in connection with another branch of the subject of this discourse, led him to consider it not impossible that the development of even very small quantities of inflammable gas or vapor from flour particles which become heated between "dry" stones to an extent to be charred, may, in some cases, decidedly facilitate the propagation of flame by a particular mixture of dust and air, which might otherwise only be bordering upon an explosive mixture.

Mr. Richards calls attention, in an appendix to his report, to four very disastrous fires which had occurred in flour mills at Wakefield, York, Liverpool, and Deptford, within two months of the completion of his report, the origin of the fire being in each case unknown. There is no doubt that the number of fires occurring in corn and rice mills, the origin of which is wrapped in obscurity, is very great; and it is stated upon good authority that only about 20 per cent. of the explosions in flour mills which can be actually substantiated are made public, the miller being unwilling to direct increased attention to the risks of his business, which, as it is, have given rise to the establishment of high rates of insurance upon corn mills. If efficient measures can be adopted in mills for preventing the dispersion of fine flour dust by other than the comparatively imperfect contrivances for promoting its partial deposition (as in the exhaust box and stive room), flour mill explosions will certainly be reduced in frequency and importance. The efficiency of at any rate one simple device for arresting the dust, by a species of filtration of the air which is removed from the millstone chambers, seems to have been already decisively demonstrated by practical results, and there appears reason to hope that the millowner will ere long have no valid excuse for permitting a continuance of conditions favorable to what have appeared to be hidden risks of danger to his property and to the lives of those whom he employs.

There appears no doubt that some instances of explosion or of very rapidly spreading fire in flour mills have been ascribable to the employment—accidentally, or with the permission of those in authority—of naked lights in the vicinity of particular parts of the factory where dust may be thrown into the air in large quantities. An explosion from this cause occurred at the mills of Messrs. Ellis & Co., of Bradford. A spout from a sieve having become choked, a man removed the lid; a quantity of dust at once flew out, and the mixture, meeting either a lamp in the man's hand or a naked gas flame close by, exploded, rendering the man insensible; the flame passed along an inclosed belt to a box containing a fan which was driving a blast of air into five purifying chambers; these purifiers were fired simultaneously, and the explosion then passed to the adjacent exhaust purifiers, and thence to the dust room, so that the mill was fired throughout almost immediately. In another instance the floor of a meal chamber broke, letting through the floor, which, on falling into the air, was ignited by a flame in the vicinity, and speedily fired the mill. Judging from statements made at a recent meeting of the National Association of British and Irish Millers, the opinion is entertained by many millowners that the running of millstones empty must not be credited with too great a share in the origination of explosions or fires in mills; but that many are caused by the so-called accidental ignition (by naked flames) of dust and air mixtures. If such be the case, grave responsibilities are incurred by millowners and managers who permit the existence of lights other than safety lamps in localities where there is any possibility of a considerable quantity of dust becoming suspended in the air, or do not establish and strictly enforce regulations prohibiting the carrying of naked lights in or near any working part of the mill.

The important part played by coal dust, which exists in greater or less abundance in all coal mine workings, in aggravating and extending the injurious effects of fire damp explosions, was originally pointed out with great force by Messrs. Faraday and Lyell, in the report which they submitted to the Home Secretary in 1845, on the explosion at the Haswell Collieries in September, 1844, and on the means of preventing similar accidents. It does not come within the scope of this discourse to examine into the chief part of this most interesting and instructive report, which deals exhaustively with the cause of the explosion and the means of guarding against the recurrence of such a calamity; but the lecturer, having had occasion to study carefully what has been published on the subject of coal mine explosions and their causes within the last three years, cannot forbear pointing out that the observations and conclusions published by Faraday and Lyell thirty-seven years ago have been repeatedly reclothed with the garb of originality by workers who have but extended and amplified the original observations of those eminent men.

After discussing the subject of the accumulation of fire damp in the goaves of the mines, its dislodgment by the drawing of juds, by falls of the roofs in the goaves, and by changes in atmospheric pressure, its diffusion into the surrounding air in the mine ways, its ignition by a defective lamp, and the spreading of the flame to the gas mixture, with which the goaf was charged, the reporters say: "In considering the extent of the fire from the moment of the explosion, it is not to be supposed the fire-damp was its only fuel; the coal dust swept by the rush of wind and flame from the floor, roof, and walls of works would instantly take fire and burn, if there were oxygen enough present in the air to support its combustion; and we found the dust adhering to the faces of the pillars, props, and walls in the direction of and on the side toward the explosion, increasing gradually to a certain distance as we neared the place of ignition. This deposit was in some parts half an inch, in others almost an inch thick; it adhered together in a friable coked state. When examined with the glass it presented the fused round form of burnt coal dust, and when examined chemically, and compared with the coal itself reduced to powder, was found deprived of the greater portion of the bitumen, and in some instances entirely destitute of it. There is every reason to believe that much coal gas was made from this dust in the very air itself of the mine, by the flame of the fire-damp, which raised and swept it along, and much of the carbon of this dust remained unburnt only for want of air.

"At first we were greatly embarrassed by the circumstance of the large number of deaths from choke damp, and in the evidence that *that* had been present in very considerable quantities compared with the small proportion of fire-damp, which, in the opinion of those in and about the works just before, must have occasioned the explosion. But on consideration of the character of the goaves as reservoirs for gaseous fuel, *and the effect of dust in the mine*, we are satisfied that these circumstances fully account for the apparent discrepancy."

On January 17, 1845, Faraday delivered a discourse to the members of the Royal Institution in which he dealt with the substance of the above report, and with the experimental inquiry made by himself with reference to the provision of means for preventing a recurrence of such disasters as that at Haswell. In a brief account of this lecture published in the number of the *Athenæum* following its delivery, the substance of his remarks relating to the effect of coal dust is given in these words: "The ignition and explosion of the (fire damp) mixture would raise and then kindle the coal dust which is always pervading the passages, and these effects must in a moment have made the part of the mine which was the scene of the calamity glow like a furnace."

The report of Faraday and Lyell was published in the *Philosophical Magazine* for January, 1845, and was followed by a letter from Faraday in the February number of the same publication, in which he referred to the lecture just delivered at the Royal Institution, and made further suggestions with respect to the method of ventilating the mines suggested in the report. But it appears that these publications remained long unknown in France, for in 1855 M. Du Souich, Chief Government Mining Engineer of the Saint Etienne arrondissement, when referring to an explosion which had occurred at Firminy, advanced, as new, the view that the deposition of crusts of a light coke upon the props was due to dust which was swept up and transported to a distance by the violent current produced by the explosion, and which, being in part inflamed, would carry on and prolong the effects of the fire-damp. The fact that men near the pit's mouth received burns and other injuries, while others who were in workings near the seat of the explosion, but out of the main air current, escaped unhurt, was ascribed by him to this ignition and carriage of flame by dust. Had the results of the explosion been entirely due to the mine being highly charged with gas, the explosion must, he considered, have extended to those portions. On the occasion of two explosions in 1861, M. Du Souich again dwelt upon his views regarding the part played by coal dust in increasing the disastrous effects of fire-damp explosions. In 1864–67 M. Verpilleux instituted experiments which led him to the conclusion that coal dust plays an important part in coal-mine explosions; the subject was also pursued by several other French mining engineers at about the same time, and especially by M. Vital, who made some experiments on a small scale, in 1875, in connection with an inquiry into the nature and cause of an explosion which had occurred the year before at the Campagnac Colliery, and in a part where no fire-damp had ever been detected. An examination for gas had been made by the overman with a Mueseler lamp just before a shot was fired, and after the first shot a second shot was prepared and, the fuze having been ignited, the men retreated, when after a short interval an explosion took place, and the men stated that they saw a body of reddish flame advancing upon them. After examining the nature of dust collected in the mine, and instituting some special experiments upon a very small scale for the purpose of ascertaining whether, and to what extent, the flame from a small charge of powder was lengthened, when projected, like the flame from a blown out shot, into air containing fine coal dust in suspension, M. Vital concluded that very fine coal dust, very rich in volatile (inflammable) constituents, will take fire when raised by an explosion, and that portions of the coal are successively decomposed, yielding explosive mixtures with the air, whereby the fire is carried along; the intensity or violence of the burning being much influenced by the physical characters (fineness, etc.) of the dust. He also pointed out that an explosion of fire damp, while taking place almost instantaneously, inflames or decomposes a small quantity of coal dust raised thereby; explosive action being thus propagated after the fire-damp explosion has ceased. Soon after M. Vital's investigation of the subject, Mr. W. Galloway commenced a series of valuable experiments upon a larger scale, with the view of investigating the influence of coal dust in colliery explosions, and the results were communicated by him to the Royal Society in two papers in 1876 and 1879. The conclusions to which Mr. Galloway was led by the experiments described in his first paper were to the effect that a mixture of air and a particular coal dust which had been made the subject of chemical examination and practical experiment was not inflammable at the ordinary pressure and temperature, but that the presence of a very small proportion of fire-damp in the air, the existence of which could not be detected with a Davy lamp by the most experienced observer, rendered this dust inflammable, and caused it to burn freely with a red, smoky flame. From this it was inferred that an explosion, when originated in any way whatever in a dry and dusty mine, may extend itself to remote parts of the workings, where the presence of fire-damp was quite unsuspected.

In his second paper, Mr. Galloway shows that the return air of a fiery mine which, though furnishing no indication of the presence of gas when examined in the usual way (by means of a Davy safety lamp), might in his opinion contain from 2 to 2·5 per cent., may be rendered inflammable by suspending coal dust in it. He also described experiments by which it appeared to be demonstrated that the flame produced by the explosion of fire-damp in a particular part of a mine might be propagated, at any rate to some extent, by coal dust raised by the explosion and suspended in the air traveling through the mine, even in the *complete absence* of

fire-damping the air. The apparatus used by Mr. Galloway was constructed on a somewhat extensive scale. In connection with the channel or gallery through which a current of air, with or without coal dust in suspension, was passed, was a receptacle in which a mixture of pit gas (from Llwynpia Colliery) and of air was prepared and exploded. The direct communication between the gas vessel and the gallery (representing a mine way) was only interrupted by a diaphragm composed of from 2 to 6 leaves of newspaper; this separator being burst through by the explosion of a mixture of nearly two cubic feet of fire-damp with the requisite proportion of air. The coal dust was placed on the floor of the gallery and upon certain shelves fixed in it. It appeared open to question whether, with the employment of this apparatus, there was not a possibility of very small quantities of fire damp penetrating, before the explosion, into the gallery from the explosive chamber, through the closing arrangement above alluded to, and whether the results obtained in the gallery might, consequently, be accepted as produced solely by the effect of the concussion produced and flame promoted by the gas explosion in the separate chamber.

In a paper just communicated to the Royal Society, Mr. Galloway argues that any amount of gas which may thus escape into the gallery must be altogether insignificant as regards any possible influence upon the results obtained.

The conclusion now arrived at by Mr. Galloway, as the result of continued experiments with this apparatus, of which he has just given a further account, and of his examination into the effects produced by the Penygraig explosion in December, 1880, and the Risca and Seaham explosions of that year, is confirmatory of that published by him last year, namely, that the very decided view which he first held, "that a mixture of air and coal-dust is not inflammable at ordinary pressure and temperature without the presence of a small proportion of fire damp," has not been borne out by his further experiments, as he considers that he has now shown "conclusively that fire-damp is altogether unnecessary for the propagation of flame with explosive effects by a mixture of coal dust and air," when the scale on which the experiments are made is large enough, and when the fineness and dryness of the dust are "unquestionable."

This conclusion coincides in the main with that arrived at in 1878, as the result of experiments by Prof. Freire Marreco, conducted in connection with the North of England Institute of Mining and Mechanical Engineers, which society, as well as the Chesterfield and Derbyshire Institute of Engineers, has labored very usefully in this direction contemporaneously with Mr. Galloway. The most recent conclusions of the latter in respect to coal dust were in fact forestalled by those which the late lamented Professor Marreco, in association with Mr. P. D. Morison, communicated to the first named institute in November, 1878, and which were published in its *Transactions* of that date.

Messrs. Marreco and Morison's experiments were carried out in galleries or long boxes, representing mine workings, though on a smaller scale than Mr. Galloway's later apparatus, and constructed somewhat differently in their details. The apparatus used by them at Harton Colliery (and with which experiments have since been continued by Messrs. Lindsay Wood and G. May) was in fact a double gallery, so arranged that the air current which passed into one gallery made its exit at the end of the second, alongside the point of its first entrance. The mode of proceeding was to fire successively two powder shots, in different positions in the gallery box, from small cannon, so as to represent blown out shots in the effects produced; coal-dust was placed upon the floor of the box, and one shot was first fired against the air current which was passing at a known velocity. The dust-cloud thereby raised was carried along by the current, and a second shot was fired into it, and in a large number of experiments made with many different descriptions of dust, the flame produced by the second shot was increased by that of inflamed dust, a comparatively clear flame being sometimes produced, while in other instances it was accompanied by a shower of sparks. The view taken by Vital, Marreco, and others, regarding the action of coal-dust in propagating flame in air free from fire-damp, is to the effect that the first portions of dust acted upon by the inflamed gases of the shot liberate inflammable gas which mixes with the air, and is fired, the non-volatile part of the coal being in part consumed and in part deposited as a feeble coke. Some examination of coked deposits of dust sent to Marreco subsequently by Mr. Galloway confirmed the observations originally made by Faraday and Lyell, that the coal-dust is in part submitted to destructive distillation during the progress of the flame through the dust-laden air. Marreco considers that, although a proportion of the heat developed by the burning dust is absorbed by the gasification of the coal-constituents, the heat of combustion of these suffices to leave a margin for the carrying on of the action from one particle of dust to another, provided these be in sufficiently close proximity to each other.

In the experiments made by the Chesterfield and Derbyshire Institute of Engineers, in a very long gallery, results were obtained very similar to those of Marreco and Morison, and it was also found that a lengthening of a gas flame, which was placed in the gallery, could be obtained by causing the current of air to carry with it thick clouds of some descriptions of coal dust.

Many instances are on record in this country and others of the firing, with semi-explosive violence, of clouds of coal dust, produced either in the open air or in localities where no fire-damp could exist, some portions of the mixture of dust and air having come into contact with a flame or fire. Thus Marreco and Morison mention a case of a considerable quantity of coal dust, which had been accidentally thrown over some screens at a pit's mouth, flashing into flame as the dust-cloud came into contact with a neighboring fire, and burning a man very severely; and another accident, which occurred in a stone-drift, where it was believed that no gas could possibly be present. A considerable body of rock was dislodged and coal dust raised by the firing of a shot, the flame of which fired the air and dust mixture, with very mischievous results. From 50,000 to 60,000 cubic feet of fresh air were said to be passing through the drift per minute when this accident occurred.

There appear good grounds for believing that, provided coal dust be sufficiently fine and thickly suspended in the air, and of a readily inflammable nature, fire may travel to a considerable distance in the working of a mine, through its agency, in the complete absence of fire-damp. The effects of transmission of flame in this way would be decidedly different, and much inferior in violence, to those produced by an explosion of fire-damp and air, or of a mixture of these with coal dust; the comparative suddenness of the gas explosion would produce greater destruction and less burning effects than the comparatively gradual explosion, or the rapid burning of a dust and air mixture. In the latter case the coal dust will generally be considerably in excess of the air needed for its combustion, so that, however finely divided, much will escape being burned, and may be only very partially coked; and it is conceivable that, as suggested by Mr. Galloway, a second rapid burning or semi-explosion may be caused by the inrush of air, following the first explosion, into the workings which may be thick with heated and only partially burned dust, some of which may still be incandescent.

Considering that, since first Faraday and Lyell directed attention to the dangers of coal dust in mines, its behavior has been made the subject of many series of experiments and published reports here and abroad, it is remarkable that in most instances of coal-mine explosions, until quite recently, the probable effect of coal dust in increasing their magnitude does not appear to have received the serious attention which it merits at the hands of mine-owners and of those in authority connected with coal-mines. When the Royal Commission on Accidents in Mines was appointed, it collected evidence from Her Majesty's inspectors of mines, from experienced colliery owners and mining engineers, and from selected pitmen, with respect to the causes of accidents, and that evidence included several statements regarding the possible influence of coal dust in aggravating explosions, but the preponderance of opinion of Her Majesty's inspectors was against the view that explosions could originate with, or be to any great extent propagated by coal dust *in the absence* of fire-damp. The only experiment on a practical scale bearing upon the subject which appears to have been made until quite recently is that of Mr. H. Hall, Mine Inspector of the North Wales, etc., district, who, in firing charges of 4 lb. of powder from a cannon in an adit driven about 50 yards from the surface in a coal seam on the dip, coal dust being sprinkled upon the floor, obtained flame extending to distances of 30 to 60 yards, while without the dust the flame of the shot did not extend more than 6 or 7 yards.* Some decided opinions were expressed that the supposed influence of coal dust in aggravating explosions was overrated, and that it would certainly not lead to explosions in the absence of gas. On the other hand, Mr. Galloway expressed a strong opinion that some of the most extensive of recent explosions, such as those at Llan and Abercarne, were at any rate largely contributed to by coal dust, and more recently—on the occasion of the inquiry into the Penygraig explosion—he gave evidence to the effect that the disastrous results of this explosion were mainly, if not entirely, ascribable to the action of coal dust, supporting this opinion by the results of a minute examination into the condition of the pit, of the sufferers, etc., after the accident.

When the terrible calamity which occurred at Seaham Colliery in September, 1880, was officially inquired into, the suggestion was very decidedly put forward by the miners' representatives, that the coal dust which existed in large quantities in some parts of the mine, and especially near the spot where it was surmised that the explosion had originated, might have had much to do with the accident. Indeed the opinion was strongly entertained by some that it was entirely due to the ignition of coal dust, in the absence of gas, by the flame from a blown out shot. The lecturer was consequently requested by the Home Secretary to make experiments with samples of dust collected in different parts of the mine, and the results obtained with them led to an extension of experiments with dust from other collieries in different parts of the kingdom. These experiments, carried to a certain point for the immediate purpose of the Seaham inquiry, have been interrupted for some time, but the Royal Commission has now resumed them with the object of obtaining more precise data in connection with certain results which were elicited by the first part of the investigation.

The earlier experiments were carried on at the Garswood Hall Colliery, where a constant and abundant supply of pit gas (a so-called blower) is brought to the surface, and was kindly placed at the service of the Commission by Messrs. Smethurst & Co., together with many conveniences, for the purposes of these and other important experiments upon which they have been engaged. The apparatus used at Garswood for the experiments with the Seaham and other dusts was similar in character to those employed by Freire Marreco, Galloway, and others, great pains being taken to secure accuracy and uniformity in the velocity of the air currents passing through the gallery, in the proportion of pit-gas, or fire-damp, used with the air, and in the intimacy of the mixture. In order to raise the air current in the gallery to a temperature similar to that of the atmosphere in colliery workings, the air supply was drawn through a system of heated pipes, so that, when passing at as high a velocity as 1,000 feet per minute, its temperature would be raised up to 80° or 85° F. even in the very severe weather during which some of these experiments were made.

The samples of coal dust experimented with were examined with respect to fineness, proportions of volatile matter and ash, and one or two other points, and they were all carefully dried before use.

Experiments were made in the first instance with a view of ascertaining the smallest proportion of fire-damp which, when mixed with the air passing through the apparatus, would furnish an atmosphere capable of firing at a naked flame of a particular size, placed in the gallery. It was next ascertained what quantity of gas below that proportion was needed to impart to the mixture of air with a large quantity of each particular coal dust the property of exploding throughout the gallery. By these experiments the samples were classed in the order of their sensitiveness to explosion, and it was found that those which were very rich in pure coal, and which contained the highest proportion of very fine dust, were the most sensitive, *i. e.*, required the lowest proportions of fire-damp in air to bring them to explode readily when suspended in a dense cloud. But with the samples containing larger proportions of non-combustible matter the order of sensitiveness did not necessarily harmonize with the comparative richness of a sample in pure coal, nor with its comparative fineness, and this was strikingly illustrated by a sample of dust from one of the roads in Seaham Colliery, which contained more than half its weight of non-combustible matter, yet ranked only third in order of sensitiveness, while another sample, containing considerably more coal and a somewhat larger proportion of the finer dust, ranked fifth.

Another point clearly established, and confirming by more accurate data the observations of earlier experiments, was that the proportion of fire-damp required in a mine to bring dust into operation as a readily exploding material when thickly suspended in the air is bordering upon and even below the smallest amount which can be detected in the atmosphere of a mine, by the most practiced observer, with the use of the Davy lamp, the only means of searching for gas which has until quite recently been employed in mines. The highest proportion which can thus be detected by an experienced operator is stated to be about 2 per cent. Explosions were produced by dusts suspended in air traveling at a velocity of 600 feet per minute, when fire-damp was present in proportions ranging from 2 to 2·75 per cent.; in currents of low velocity the same result was produced with a sensitive dust in the presence of only 1·5 per cent. of fire-damp, and ignitions which approached explosions in their nature and extended to considerable distances were obtained with this dust in air containing still smaller proportions of gas. Mixtures of fire-damp and air bordering upon those which will ignite upon the approach of flame were found to be instantaneously fired by a lamp if they contained only a few particles of dust in suspension; and in connection with this fact the interesting observation was made that such dust particles need not be inflammable nor combustible to produce the result named. Mixtures of air and gas which passed a naked flame without any symptom of ignition were inflamed when particles of a fine light powder, such as calcined magnesia, were suspended in them. The action of certain of the pit dusts which contain comparatively little coal, in determining the ignition of mixtures of air and small proportions of fire-damp, is possibly of the same character as the behavior of such a dust as calcined magnesia. The power of favoring the ignition of mixtures of fire-damp and air was not exhibited by some other powders similar in fineness to the latter, but differing in structure and density from this and one or two other non-combustible dusts which may be called active; and even different samples of magnesia differing somewhat in lightness from each other, appeared to possess the activity in different degrees. These facts seem to favor the view that a dust possessing particular physical characteristics exerts a contact or catalytic action upon gas mixtures, similar to that known to be possessed by platinum and some other substances under particular conditions. Thus, when finely divided platinum or even a clean recently heated surface of the compact metal is brought into contact with mixtures of hydrogen, or a hydrocarbon gas or vapor, with oxygen or air, oxidation of the hydrogen or hydrocarbon is at once established, accompanied by the development of heat, whereby the temperature of the metal is raised and chemical activity promoted, so that heat speedily accumulates, raising the metal to a temperature sufficiently high to bring the surrounding gas mixture to the exploding point. If the metal presents a very large surface, or is in a specially porous condition, as in the form of sponge or very fine powder (*platinum black*), the explosion of the gas mixture may follow very rapidly, or almost instantly, upon the first contact of some portion with it.*

In many of the experiments with calcined magnesia just referred to, it was distinctly noticed that a dark space intervened between the gas flame used as the source of heat and the flare produced by the ignition of the gas mixture through the influence of the dust cloud suspended in it, which would seem to indicate that the dust particles, immediately upon passing through the flame, established some amount of oxidation of the fire-damp, which proceeded with increased rapidity as the dust became more highly heated through the chemical action developed, so that within a short distance from the point where the heating commenced the dust became incandescent, and the ignition of the gas mixture followed. Further experiments which are contemplated may elucidate the precise nature of this action of non-combustible dust in promoting the ignition of gas mixtures which, in the absence of dust, are not inflammable. There appears little doubt, however, that it constitutes one element in the dangers arising from the presence of dust in the air of a mine which contains a small proportion of fire-damp, and in which a large body of flame is accidentally produced, either by a blown out shot, or by a fire-damp explosion of local character.

[*To be continued.*]

LIEBIG.

IN industrial history the name of Liebig will always be affectionately and admiringly cherished as the designation of a man who more than any other of the century gave an impetus to the commercial and industrial applications of chemistry. His life, apart from this fact, is an example to succeeding generations of scientific inquirers in the industry and indefatigable energy with which it is characterized. He was born at Darmstadt in 1803, and after a preliminary education at the Gymnasium in his native town, and a short apprenticeship to an apothecary, he entered the University of Bonn in 1819. In 1822 he visited Paris, where, with the assistance of the Duke of Hesse-Darmstadt, he studied chemistry for two years. In 1824 he read a paper before the French Institute on "The Chemical Composition of Fulminate," which attracted the attention of Humboldt, by whose influence Liebig obtained the post of Adjunct Professor of Chemistry at Giessen. In 1826 he was made Professor, and the laboratory he established for teaching practical chemistry became the resort *par excellence* for students from different parts of the world. In 1832 Liebig wrote the *Amateur de Pharmacie*. In 1838 he visited England and read an important paper before the British Association, and in 1840 he issued, in response to the Association, a work subsequently translated by one of his most distinguished pupils, Dr. Lyon Playfair, under the title of "Chemistry in its Application to Agriculture and Physiology." This work was followed by the well-known *Chemische Briefe*, translated into English under the title of "Familiar Letters on Chemistry, and its Relations to Commerce, Physiology, and Agriculture." In 1842 Liebig penned a second work at the request of the British Association. This was entitled in its translation, "Animal Chemistry, or Chemistry in its Application to Physiology and Pathology." The investigations embodied in this work succeeded in directing Liebig's attention more especially to the nature and proper applications of medicines and food, and in 1847 and 1848 respectively he produced the results of these investigations in the shape of two works entitled "Researches on the Chemistry of Food" and "The Motions of the Juices in the Animal Body." Liebig was also concerned in a number of other publications, without mentioning his voluminous contributions to periodical scientific literature. With Puffendorff he compiled the *Handworterbuch der Chemie*, and he

* Mr. Hall stated that the air in this adit was "practically" free from gas, but did not maintain its *absolute* freedom.

* This action of platinum (or palladium) has recently received applications bearing special reference to the existence of explosive gas mixtures in coal mines. The one consists in an apparatus proposed by Mr. Korner for removing, by slow combustion, local accumulations of fire-damp; the other is a very simple and portable photometric apparatus, devised by Mr G. H Liveing, by which proportions of fire-damp much lower than the smallest amount discoverable by the Davy lamp in the hands of the most expert can be readily and quickly detected, and the amount estimated with considerable accuracy.

contributed to Geiger's *Handbuch der Pharmacie* the portion devoted to organic chemistry. In 1841 he furnished the organic portion of Dr. Turner's "Elements of Chemistry." In 1848 he established, in connection with Professor Kopp, an annual report on the progress of chemistry, which has continued to the present time. In 1855 appeared his *Grundsatze der Agriculturchemie*, in 1856 *Theorie und Praxis der Landwirthschaft*, and in 1859 *Naturwissenschaftliche Briefe uber die moderne Landwirthschaft*. Liebig gave much attention to the subject of the utilization of the sewage of towns, and his publications on this subject have been most useful. His last communication to the *Annalen* was a notice of the discovery of chloroform, in which he directed attention to the fact that it was discovered by himself in 1831, and not by Souberian, as was generally supposed.

Liebig had many honors conferred upon him in the course of his valuable existence, and in 1845 he was made a baron. He died at Munich in 1873.

Liebig ascertained that the soluble constituents of 34 lb. of pure muscle meat (equal to 45 lb. of ordinary meat as it is received from the butcher) may be concentrated by boiling to 1 lb. of extract, sufficient for the preparation of 190 parts of bouillon. With his keen perception he foresaw that the manufacture of this extract might become a great industry. He conceived the idea that the transmarine countries rich in cattle might become tributary to the necessities of Europe.

In the year 1850, at the beginning of the manufacture, the Royal Apothecary at Munich consumed scarcely one hundredweight annually—that is, one tenth part of an ox—and Liebig himself did not imagine that in a score of years the number of cattle falling victims to this industry would number millions. This statement will not appear exaggerated when it is considered that in the summer season there are now led daily to the slaughtering bench from one thousand to twelve hundred oxen.

LIEBIG.

The manufactory of Liebig's Extract of Meat Company lies on the eastern (left) shore of the Uruguay River in that State, and is as important to Fray Bentos as Krupp's great steel manufactory is to Essen.—*Industry.*

THE DECAPITATED DRINKING HORSE.

The optical illusion known as the talking decapitated person is perhaps well known to our readers. The ancients invented an analogous trick, but one that was founded upon a very ingenious mechanical combination. This is found described at the end of Heron's *Pneumatics* under the title: "To cut an animal in two and make him drink." It is as follows:

Let us suppose a hollow pedestal, A B C D, divided in its center by a diaphragm, E F (Fig. 1). Above the pedestal there is fixed a statuette representing a horse and traversed by a tube, M N, which terminates on the one hand in the horse's mouth, and in the other in the upper part of the compartment, A B E F, after following one of the legs. It will be conceived, in the first place, that if the said compartment be filled with water through an aperture, T, which is afterward stopped up, and that then a cock be opened, so as to form a communication between the upper compartment and the lower (which latter is itself provided with an open air-hole), the water will flow, and, in doing so, tend to cause a vacuum in the tube, M N, so that, when a vessel of water is brought near the animal's mouth, the water will be sucked up.

If the cock be so arranged as to present its key upon the top of the pedestal, and if to the key there be adapted a statuette representing a man armed with a club, things may be so arranged that the animal shall drink when the man has his back turned, for example, and that he shall stop drinking when the man threatens him with the club.

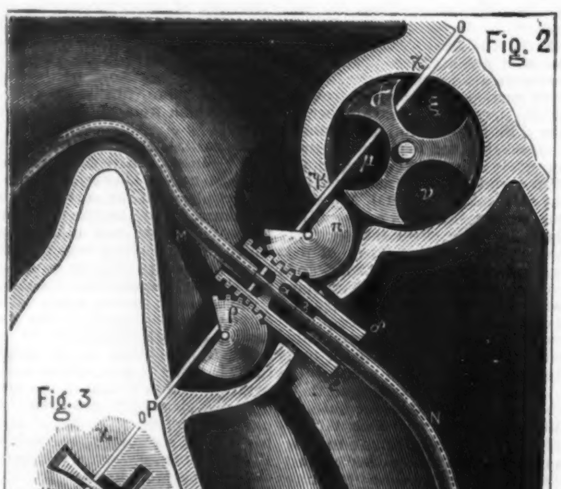
The following is the way in which a knife may be passed through the animal's neck without causing the head to fall or interrupting communication between the mouth and pedestal. The head and body form two distinct pieces, which are adjusted according to the plane, O P (Figs. 1, 2, and 3). The tube, M N, is interrupted to the right of this slit, and the two parts of it are connected by a smaller tube, $\alpha\beta$, which enters by slight friction into the interior of each of them; and to this small tube, $\alpha\beta$, there are fixed two racks δ and ε. Above δ and under ε are placed two segments of toothed wheels, π and ρ, which are movable around axles fixed in the body of the animal. Over the whole there is a third wheel, which is likewise movable around an axle fixed in the animal's body, and the thickness of which keeps increasing from the center to the circumference. This wheel is cut out into three parts of circles, μ, ν, and ξ, which have for diameters three of the sides of the inscribed hexagon. It is inclosed in the neck in such a way that the circular cavity containing it embraces just four of the sides of the inscribed hexagon, the two other sides projecting outside of the plane, O P. In the piece that forms the head a circular cavity is formed capable of containing this projecting portion of the wheel, and a wedge-shaped profile is given it, so that when one tooth of the wheel, σ, is engaged therein by the edge it can also only leave it by the edge. Let us now suppose the wheel, σ, free; let us engage one of its teeth in the cavity, $\chi\psi$; let us cause the head and body to approach; let us fix the wheel, σ, in the body by means of the movable axle traversing it; and let us introduce a knife into the slit, O P, and see what will happen.

The blade, on entering the space, ξ, will press against one of the teeth and cause it to descend until it, as well as the knife, is disengaged. The tooth above the space, ξ, will then be disengaged in its turn and connect the head with the body again. The knife-blade, which is now under the wheel, σ, rests on the inclined plane that the figure shows in the segment, π, and, on pressing thereupon, causes the wheel to turn, and, with it, the rack, δ, and the tube, $\alpha\beta$, which latter leaves the tube, M, and gives passage to the blade between it and the extremity, α. Then the blade

Fig. 1.—HERON'S DECAPITATED DRINKING HORSE.

comes in contact with the lower projection of the sector, ρ, which has been carried upward by the motion of the rack, ε, that is connected with the rack, δ. On pressing against such projection the blade causes the segment, ρ, to revolve in a contrary direction, brings ε toward the left, and causes the small tube, $\alpha\beta$, to enter anew the tube, M. Communication between M and N is thus re-established.

I have never found elsewhere than in the *Pneumatics* a description of this system of toothed wheels, although I have read the majority of books treating of this class of ideas. The description given by Heron is itself so confused and so mutilated, and the figure that accompanies it is so incomplete that in all the Latin editions it is suppressed as incomprehensible. I have seen, however, in my youth, prestidigitators pass a knife between a cane and its head, and this most certainly must have been effected by an analogous mechanism, the tradition of which has thus been preserved for more than two thousand years.—*A. De Rochas, in La Nature.*



Figs. 2 and 3.—THE DECAPITATED HORSE.—DETAILS OF THE MECHANISM IN THE NECK.

[Spirit of the Times.]

THE FASTEST RECORDS.

Table of the Best Time on Record at All Distances, and All Ways of Going, to Jan. 1, 1883.

Trotting in Harness.

One mile—Maud S., Rochester, N. Y., Aug. 11, 1881, 2.10¼, the fastest mile ever trotted, and the fastest first heat.

One mile—Maud S., Buffalo, N. Y., Aug. 4, 1881, 2.10¾, the fastest second heat ever trotted.

One mile—Maud S., Chicago, Ill., July 23, 1881, 2.11, the fastest third heat ever trotted.

One mile—Maud S., Buffalo, Aug. 4, 1880, and Hopeful, Hartford, Ct., Aug. 27, 1880, 2.16½, the fastest fourth heat ever trotted.

One mile—Smuggler, Cleveland, Ohio, July 27, 1876, 2.17½, the fastest fifth heat ever trotted.

One mile—Charlie Ford, Hartford, Ct., Aug. 25, 1880, 2.19½, the fastest sixth heat ever trotted.

One mile—Maud S., Chicago, Ill., July 24, 1880, 2.13½, the fastest heat in a race against other horses.

One mile, by a yearling—Hinda Rose, San Francisco, Cal., Nov. 24, 1881, 2.36½.

One mile, by a two year old—Wildflower, San Francisco, Cal., Oct. 22, 1881, 2.21.

One mile, by a three year old—Phil Thompson, Chicago, July 26, 1881, 2.21.

One mile, by a four year old—Jay-Eye-See, Chicago, Ill., Sept. 23, 1882, 2.19.

One mile, by a five year old—Santa Claus, Sacramento, Cal., Sept. 11, 1879, 2.18.

One mile over half mile track—Rarus, Toledo, O., July, 20, 1878, 2.16.

One mile, fastest two successive heats—Maud S., at Chicago, Ill., July 23, 1881, 2.11½, 211.

One mile, fastest three consecutive heats—Maud S., Belmont Park, Philadelphia, Pa., July 28, 1881, 2.12, 2.13¼, 2.12½.

One mile, fastest four consecutive heats—Gloster, Rochester, N. Y., Aug. 14, 1874, 2.18, 2.17¾, 2.17, 2.19, the first being a dead heat with Red Cloud; and Goldsmith Maid, Hartford, Ct., Aug. 31, 1876, 2.16¾, 2.17¼, 2.18, 2.19¾, the first (the third heat of the race) being a dead heat with Smuggler. The aggregate of the time of these two performances is equal.

Two miles—Monroe Chief, Lexington, Ky., Oct. 21, 1882, 4.46.

Three miles—Huntress, Prospect Park, L. I., Sept. 23, 1872, 7.21¼.

Four miles—Trustee, Union Course, Long Island, June 13, 1849, 11.06.

Five miles—Lady Mack, San Francisco, Cal., April 2, 1874, 13.00.

Ten miles—Controller, San Francisco, Cal., Nov. 23, 1878, 27 23¼.

Twelve miles—Topgallant, Philadelphia, Pa., 1830, 38.00.

Fifteen miles—Girder, San Francisco, Cal., Aug. 6, 1874, 47.20.

Twenty miles—Captain McGowan, Boston, Mass., Oct. 31, 1865, 58.25.

Fifty miles—Ariel, Albany, N. Y., 1846, 3.55.40½.

One hundred miles—Conqueror, Long Island, Nov. 12, 1853, 8.55 53.

One hundred and one miles—Fanny Jenks, Albany, N.Y., 1845, 9.42.57.

Trotting to Wagon.

One mile—Hopeful, Chicago, Ill., Oct. 12, 1878, 2.16½, the fastest heat ever trotted, and the fastest first heat.

One mile—Hopeful, Chicago, Ill., Oct. 12, 1878, 2.17, the fastest second heat.

One mile—Hopeful, Chicago, Ill., Oct. 12, 1878, 2.17, the fastest third heat.

One mile, drawing 2,000 pounds—Mountain Maid, Long Island, 1865, 3.24½.

Two miles—Gen. Butler, Long Island, June 18, 1863, first heat, 4.56¼; and Dexter, Long Island, Oct. 27, 1865, second heat, 4.56¼.

Three miles—Kemble Jackson, Union Course, L. I., June 1, 1853, 8.03.
Four miles—Longfellow, San Francisco, Cal., Dec. 31, 1869, 10.34½.
Five miles—Little Mack, Fashion Course, L. I., Oct. 29, 1863, 13.43½.
Twenty miles—Controller, San Francisco, Cal., April 20, 1878, 58.57.
Fifty miles—Spangle, Oct. 15, 1855, 3.59.04.

Trotting, Double Teams.

One mile—Edward and Dick Swiveller, Morrisania, N. Y., July 13, 1882, 2.16¾.
One mile with running mate—Yellow Dock and mate, Providence, R. I., Nov. 2, 1882, 2.11.
One hundred miles—Master Burke and Robin, 10.17.22.

Trotting under Saddle.

One mile—Great Eastern, Fleetwood Park, N.Y., Sept. 22, 1877, 2.15¾.
Two miles—Geo. M. Patchen, Fashion Course, L. I., July, 1, 1863, 4.56.
Three miles—Dutchman, Beacon Course, N. J., Aug. 1, 1839, 7.32½.
Four miles—Dutchman, Centreville, L. I., May, 1836, 10.51.

Pacing.

One mile, in harness—Little Brown Jug, Hartford, Ct., Aug. 24, 1881, 2.11¾, the fastest heat and fastest first heat ever paced.
One mile, in harness—Little Brown Jug, Hartford, Ct., Aug. 24, 1881, 2.11¾, the fastest second heat.
One mile, in harness—Little Brown Jug, Hartford, Ct., Aug. 24, 1881, 2.12½, the fastest third heat. These three performances make the fastest three consecutive heats ever paced, or ever made in harness.
One mile, under saddle—Billy Boyce, Buffalo, N. Y., Aug. 1, 1868, 2.14½.
One mile, to wagon—Pocahontas, Union Course, L. I., June 21, 1855, 2.17½.
Two miles, in harness—Defiance and Longfellow, Sacramento, Cal., Sept. 26, 1872 (a dead heat), 4.47¾.
Two miles, under saddle—Bowery Boy, Long Island, 1839, 5.04½.
Three miles, in harness—Harry White, San Francisco, Cal., Aug. 8, 1874, 7.57½.
Three miles, under saddle—Oneida Chief, Beacon Course, N. J., Aug. 14, 1843, 7.44.

The most important trotting performances during 1882 were as follows: The 2.19 of the four year old, Jay-Eye-See, supplanting the 2.19¾ of Trinket, made in 1879. This colt made the record twice in the same race. Next is to be noted the two miles by Monroe Chief, in 4.46, a great performance, beating the Steve Maxwell record by 2¼ seconds. In double team performances there was a complete *bouleversement*, the 2.16¾ of Edward and Dick Swiveller taking the place of the 2.20 of Lysander Boy and William H., and the 2.11 of Yellow Dock, with running mate, fairly casting in the shade the 2.14¾ of Billy D. with the same rig.

OPIUM IN AFRICA.

THE first attempt at cultivation of opium in intertropical Africa has been made at Chaima, near Mopea, about four miles from the Zambesi, and on the banks of the Quaqua. M. Guyot lately visited the place, and has described the operations to the Paris Academy. The space occupied is between the two rivers Muto and Quaqua. The fields were first sown in 1879; in 1880 the surface sown was 44 hectares; in 1881 about double that quantity; in 1881 there were 300 workers engaged, 250 of whom were blacks and 50 natives of India. The opium is gathered 75 days after sowing, whereas in India the harvest does not commence till about the one hundred and tenth day. The product per hectare was, in 1880, 55 to 60 kilogrammes of raw opium (as against 50 kilogrammes on the average in India). The water required is taken from two recently connected lagoons by means of a locomotive which raises it 5·50 meters; it then flows into the plantation through pipes. (A second machine was to be set up this year.) The plant is not subject to any parasite, but the wind at harvest-time may seriously compromise operations. The soil is worked in primitive style with the hoe; plows drawn by oxen have been tried, but these animals suffer greatly under the burning sun. The gathered opium gives off a slight odor *sui generis*. It is not supplied to commerce in its first viscous, pasty state, but is mixed with 80 per cent. of a special matter, and formed into balls of 500 grammes. These balls carefully put in cases that hold 140; at the bottom is a powder formed of the empty capsules and leaves of the poppies and a layer of cotton. Sent to India the Zambesi opium fetches 50 f. to 60 f. the kilogramme.—*London Times.*

AMERICAN VINES IN SOUTHERN FRANCE.

IN September last, M. Armand Lalande, Deputy of the Gironde, visited the departments of Herault and Gard to observe the results of the efforts there being made to restore the vineyards that had been devastated by the phylloxera. Among his more interesting observations are the following:

On the 5th of September we successively visited the environs of Montpellier.

Our first visit was to the domain of Vivier, belonging to Mr. Pagezy, who, some years ago, had all of his French vines destroyed. His vineyard now presents the interesting example of thorough restoration by the American vines which were planted ten years ago. The Clinton being used, grafted next on French vines, resists perfectly well the phylloxera; the Clinton is not, however, considered the best vine for grafting.

Our second visit was to the vineyard of Rother, owned by Madame St. Pierre, widow of the eminent and regretted director of the Agricultural School of Montpellier. This vineyard is one of the best cared for that we have visited, and is very interesting.

We saw the Jacques in the highest state of cultivation; and also saw French vines grafted on the Jacques, Clinton, Taylor, and Riparia. They presented a most beautiful and satisfactory aspect, with promise of an abundant yield. The vines grafted on the Riparia have a stronger vegetation than the others. On seeing such gratifying results obtained by the production of French vines grafted on American cuttings, it gives a hope that our destroyed vineyards may be restored.

We next proceeded to the vineyard of Mr. Jules Leenbardt, one of the most intelligent vine growers of this country. He was one of the first to propagate the American vines, and his immense estate presents a most satisfactory and encouraging appearance on account of the American vines cultivated as direct production, as the Jacques and also the grafted American vines, which have, like those of Madame St. Pierre, a beautiful vegetation and an abundant production.

Our next visit was to the Agricultural School of Gaillarde, where we saw numerous samples of nearly all the varieties of American vines introduced into France. We found fields of Jacques and D'Herbmont showing fine vegetation and sufficient fruit, but much less than the French vines grafted on American roots. We have observed with much pleasure in this school a certain number of stocks of one of our fine varieties of Medee, the Carmenet-sauvignon grafted on the Riparia, showing a rich vegetation and fine production. At the domain of Mr. Ernest Leenhardt we saw magnificent Jacques and French vines grafted on American vines, full of vigor and loaded with fruit.

On September 6 we visited the splendid vineyards of Valantres, and the Chateau Pignan, belonging to the Count de Turenne. Some years since, the vines of these vineyards were entirely destroyed by the phylloxera. A few years ago he replanted 90 hectares, nearly all in Ripiria, which were afterward grafted on French vines with the greatest success. We also observed extensive fields of "Aramous" grafted since four years on Riparias which had been planted two years before. The results are splendid, the vegetation vigorous, the production abundant. All the vines are full of magnificent grapes well nourished, and the growth so great that many vines have shoots five yards long. We were informed here as elsewhere that French vines grafted on American roots produced a more abundant yield than the native vine ungrafted. In the field we have just spoken of, we were told that the direct product used to be from 150 to 160 hectoliters of wine to the hectare. It is estimated that this year it will be 220 hectoliters to the hectare; and this did not seem an exaggeration.

After quitting Valantres we went to the vineyard of Mr. Arnat, lawyer, at Montpellier. There again we saw French vines grafted on American stocks and giving a prosperous growth and an abundant production. The same day we visited the estate of Mr. De la Sorres, which serves as a field for experiment to the Agricultural School of Montpellier. We again saw interesting fields of Jacques and grafted American vines.

On September 8 we visited the property of Mr. James Chum and that of Mr. Leonce Guiraud, at Vilary. Everywhere we admired the beautiful vegetation of the American vines and the abundant production of French vines grafted on American stocks. Mr Giraud has devoted extensive fields to experimenting in the cultivation of American vines to observe the strength of their vegetation, their power of resistance to the phylloxera, and their value as direct production, and for grafting. Mr. Guiraud is especially pleased with the Herbemont as a good direct production; that is mainly due to the soil in which it is cultivated. It is the Jacques which is generally preferred.

September 9 we devoted entirely to visiting the vast estate of the Duchess Fitz James. We have admired there what we have mentioned above, American vines (principally the Jacques) cultivated for direct production; also noticed with agreeable pleasure American vines grafted on French stock. The energy and intelligence with which the Duchess has restored her vineyards commanded our highest admiration. Some idea can be formed when we state that she has already successfully planted 510 hectares, and she intends increasing this to 800 hectares. The courage, confidence, and example of the Duchess Fitz James and other large vine growers have contributed in a great measure to convince other vine growers of Languedoc that the once magnificent vineyards now completely destroyed can be gradually restored by the introduction of American vines. The department of Gard, which had 102,000 hectares of vines, has lost 100,000. The department of Herault, which has produced 15,000,000 of hectoliters of wine, produced only 3,000,000 in 1881. This year it is estimated that the yield will be only 1,500,000 hectoliters, and that next year it will not produce any. It is said that in the spring of 1883 about 51,000 hectares of American vines will be planted, and considerably more the next year.

From information given to us, we find in the departments of Herault and Gard that nearly all the vine growers have a decided preference for two varieties of the American vines: 1st, the Jacques as a direct production, and also for grafting; 2d, the Riparia for grafting. There are other varieties besides the Riparia considered very good for grafting, namely, the Clinton, Viola, Solanis, York, Madeira, and Rupestris. Generally, the grafts are planted in cuttings on the place to be grafted after they have their second leaf. On account of what we have said, it must not be supposed that we give our first preference to the Jacques as a direct product, or to the Riparia for grafts. The Jacques is more exposed in the Gironde than in the Languedoc, owing to the ravages of the arithranose and the mildew. In some of our soils the Herbemont may be advantageously substituted for the Jacques. The Riparia is, however, supposed to be the best for grafting, although the Viola and Solanis may do better. These remarks are of great importance, as no absolute or general rule can be indicated. Nothing is better than experience to aid in judging the different soils.

It is to our compatriot of the Gironde, M. Laliman, that we are indebted for first introducing the American vines to resist the phylloxera. He shares with other prominent gentlemen the honor of having indicated to the French vine growers three methods that can be employed, according to place and circumstances, to successfully combat the terrible scourge, namely, insecticides, submersion, and American vines.

ARMAND LALANDE,
Deputy of the Gironde.

A REMARKABLE GRAPEVINE.

IN the phylloxera age in which we are living, it will prove of interest to call attention to a chasselas grapevine which has greatly excited the curiosity of connoisseurs by its astonishing fecundity. A Marseilles journal, which has been sent us, announces that a vine at La Roche-sur-Yon produced this year 2,115 bunches of grapes. Having signified our desire to obtain further information on the subject, M. Emile Amiand has sent us a photograph, which we reproduce herewith, representing the extraordinary vine growing against the side of the stone house over which it has spread. This house, which is situated in Rue Moliere, belongs to M. Mornet, a shoemaker, who has had the goodness to transmit to us a few details regarding his extraordinary plant. This gentleman says:

REMARKABLE GRAPEVINE AT LA ROCHE-SUR-YON, FRANCE.

"The extraordinary vine in question is a gray chasselas of Fontainebleau planted between the pavements along the side of the house. The earth is spaded up around the base, and horse manure put in twice a year. All the branches are pruned as short as possible at the extremities, on the first of April, this being very essential. As soon as the buds put forth, the branches are nipped off at the second leaf above the buds, and, during the whole year, care is taken to keep removing the suckers in order that the sap may accumulate toward those organs which are destined to give a great development to the fruit, while securing a more active vitality in the vine, this giving proof of a much greater yield of fruit every year. This year (1882) the vine has borne 2,115 quite full bunches. This large product is due to the fact that the extremities of the branches are cut short in order that the sap may stop in the lower parts, so that the crop shall receive more vigor and be greater. To obtain a like crop, with an early and sure maturity, during the month of July all the leaves are removed."—*La Nature.*

THE FLOWERS OF MUMMY GARLANDS.

IN an interesting article which appeared in the *Academy* of September, Miss Amelia B. Edwards describes some curious additions to the Boolak Museum. Several of the royal mummies discovered last year at Dayr-el-baharee were, it will be remembered, found garlanded with flowers, those flowers being for the most part in as perfect preservation as the specimen plants in a "*Hortus Siccus.*" M. Arthur Rhone, in a recent letter to *Le Temps*, has described the extremely curious way in which these garlands are woven. They consist of the petals and sepals of various flowers, detached from their stems, and inclosed each in a folded leaf of either the Egyptian willow (*Salix salsaf*) or the *Mimusops kummel*, Bruce. The floral ornaments thus devised were then arranged in rows (the points being all set one way) and connected by means of a thread of date-leaf fiber woven in a kind of chain stitch. The whole resembles a coarse "edging" of vegetable lace work. Among the flowers thus preserved are the bright blue blossoms of the *Delphinium orientalis*, or larkspur; the blue lotus, or *Nymphæa cærulea*; the white of *Nymphæa lotus*, with pink tipped sepals; the blossoms of the *Sesbania ægyptiaca*; and the orange-hued flower of the *Carthamus tinctorius* or safflower, so largely employed as a dye by the ancient inhabitants of the Nile valley. The dried fruit, as well as the dried yellow blossom, of the *Acacia nilotica* is likewise present; and mention is also made of the blossom of a species of watermelon now extinct. The foregoing are all interwoven in the

garlands in which the mummy of Amenhotep I. was elaborately swathed.

With others of the royal mummies were found fine detached specimens of both kinds of lotus, the blue and the white, with stems, blossoms, and seed-pods complete. Still more interesting is it to learn that upon the mummy of the priest Nebseni, maternal grandfather of the King Pinotem II. (XXIst Dynasty), there was found a specimen of the lichen known to botanists as the *Parmelia furfuracea*. This plant is indigenous to the islands of the Greek Archipelago, whence it must have brought to Egypt at, or before, the period of the Her-Hor Dynasty (B.C. 1100 or B.C. 1200). Under the Arabic name of "Kheba," it is sold by the native druggists in Cairo to this day.

These frail relics of many a vanished spring have been arranged for the Boolak Museum with exquisite skill by that eminent traveler and botanist, Dr. Schweinfurth. Classified, mounted, and, so to say, illustrated by modern examples of the same flowers and plants, they fill eleven cases—a collection absolutely unique, and likely ever to remain so.

The hues of these old-world flowers are said to be as brilliant as those of their modern prototypes; and, but for the labels which show them to be three thousand years apart, no ordinary observer could distinguish between those which were buried with the Pharaohs and those which were gathered and dried only a few months ago.—*Field Naturalist.*

HUMAN FOOT-PRINTS IN STONE.

MR. W. E. WEBB, of this city, tells the *Herald* that when he was employed upon the survey of the Kansas Pacific Railroad he preserved one of a number of human foot-prints which he had carefully cut out of the native rock. The specimen has recently been shown in this city.

The stone is described as sandstone, at the top dark red, with strong traces of iron, and shading down to a light yellow at a distance of perhaps six inches from what was the surface exposed to the air some millions of years ago. The under part of it is perforated with fifteen or twenty holes, apparently worm holes, in each of which there is a soft, crumbling material, which seems to be all that is left of the unhappy prehistoric worms who got caught in the process of rock formation.

On the surface, remarkably well preserved, is the complete outline of what certainly looks like a human foot. The imprint is precisely such a one as would be made by the step of a naked foot in tolerably soft mud. The indentation of the heel is about an inch deep; that of the ball of the foot half an inch deeper; that of the big toe much less than an inch, and that of each toe (numbering from the first) a little less than the one before it. The size of the foot is that of the average man's foot to-day, perhaps a trifle smaller, but only a trifle, and the shape that of a human foot that has never been confined in a shoe. The outline is very sharp excepting around the little toe, which was apparently bent upward by the stiffness of the crust through which the foot in stepping seems to have broken, for, to judge by the appearance, the stone formation was just beginning at the time the step was taken. A thin crust, not over an eighth of an inch in thickness, had formed over the sand bed and remains distinctly visible as a stratum, being the darkest in color and the hardest part of the rock. Through this thin crust the foot broke and a similar crust has formed within the outline of the print, though this portion is rough and uneven, as if beaten upon by hard rain before it hardened into rock.

For the genuineness of this relic Mr. Webb is fully prepared to vouch, and while he fully appreciates the fact that it will hardly be accepted as the track of a human being without fierce contentions among geologists, he is yet strongly of the opinion that it was made on the eastern shore of the ocean that became the Great American Desert long after the man who made the footprint had passed away.

Seeing that the rocks of the region mentioned are of fresh water origin, the opinion expressed by Mr. Webb is very likely to be questioned by geologists. The age of the track is sufficiently great if it is really in sand rock of like formation. From the description of the track, however, it seems quite possible that it may have been made in a recent sand bed cemented or encrusted by mineral water from a hot spring.

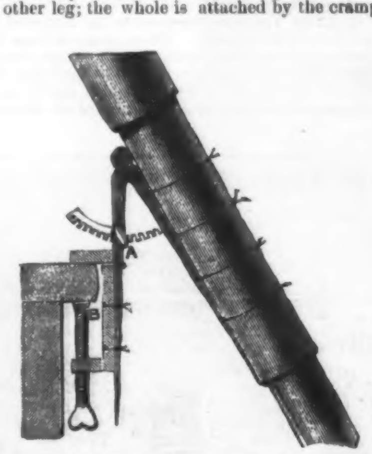
THE HOME OF THE ZUNIS.

A CONSIDERABLE party of ladies and gentlemen under the guidance of Colonel Stevenson, who is engaged in the Government Ethnological researches, lately visited the ancient pueblo of Zuni, south of Fort Wingate, New Mexico. In a communication to the New York *Tribune*, one of the party says: Zuni is the largest pueblo I have yet seen. It numbers about 1,500 people, and is so compactly built that the entire village does not cover more than six acres of ground. I had often heard that the atmosphere in and about Zuni was rendered very disagreeable by reason of the pungent odors constantly arising, and which are due to the want of care in the people's habits. There were evidences of some preparation to receive the party, but the odors were there in ample sufficiency. In addition to the want of cleanliness and decency in the daily life of men, women, and children, sheep and goat corrals are built adjoining the village and within thirty feet of some of the dwellings. The pueblo is one mass of adobe buildings. They are all connected, and though in most parts they are only one or two stories high, there are some three, and the highest point near the center of the village is five stories. I ascended to the roof of this building by means of ladders on the outside, going from one roof to another. The roofs may be reached by means of ladders from the ground from the exterior, or by entering a door and ascending by the same means on the inside, each roof having a place of exit. I saw only one flight of steps. It was very short, consisting of about half a dozen made of mud, and was on the outside of a house. The living rooms are generally of pretty fair size, some of them being as much as 20 by 40 feet. Floors are of adobe or flat stone, while the ceilings over the first floor are supported by heavy pine beams and are about eight feet high. A close layer of sticks of sufficient strength is laid across the beams as support for the floor above. In the first room I entered a woman was painting pottery previous to putting it into the kiln for burning. Their pottery designs are chiefly imitations, and they have no pieces containing any mark denoting antiquity that I could learn of. I watched them preparing a small kiln of pottery for burning. Their fuel for this consisted entirely of dried cakes of sheep manure. They rest a piece of pottery on three lumps of the manure, fill in with small bits of the fuel, then take another piece of pottery, and so on, until they get it all arranged, building in a circle, and after completely covering the entire pile with a layer of manure, they ignite it. It takes from one to two hours to burn it thoroughly. In one room a young squaw was engaged in combing the hair of an older women. I am told they spend much time in this occupation, being very proud of their hair, which is long, black, and glossy. In this operation the girl used a small stick about the size of a match to part the hair, and spitting on it occasionally she brushed it with a rude brush made of yucca, or Spanish bayonet. In nearly every house is a trough, in one end of the living room, and in it are arranged from three to five stones for grinding meal. In one place I saw a woman "grinding at the mill" in Oriental fashion.

The gardens are beyond the corrals and in one common inclosure, with each family's patch of a few rods partitioned off by a low mud wall. There is one well for the community, it being about fifteen feet in diameter, walled up and covered at the top, and is approached by a deep cut or excavation to the water's edge. From this they get all their water for houshold purposes, and much of that they use for irrigating their gardens, carrying it in ollas or pots. An old church, built by the Spaniards some three hundred years ago, still stands, though it is now in the tottering stages of decay. It is of adobe, is about one hundred and twenty-five feet long by forty wide, has a gallery, and in the rear of the altar there is still carved woodwork surmounted by a figure of the Pope in rilievo. This building has outlived its day of usefulness, and it stands there a monument of the zeal of the body that founded it, while the people it was to aid in lifting up are, after more than three centuries, still votaries of the false gods of their fathers.

STAND FOR SMALL TELESCOPE.

THE stand consists of a table cramp, fastened by means of strong copper wire or solder to one leg of a pair of joiner's screw compasses, the telescope being similarly fastened to the other leg; the whole is attached by the cramp to the



top bar of a window sash, or to the edge of a table or pair of steps. The screw of the compasses, A, gives the vertical motion, the horizontal motion being easily imparted by the bands, as the head of the cramp, B, is loose.—*English Mechanic.*

AFRICAN DISCOVERIES.

A CORRESPONDENT of a London paper who has recently been interviewing Mr. H. M. Stanley, says that gentlemen has had practically unlimited means at his command, through the generosity of the King of the Belgians, who, moreover, has been the main supporter of several of the so-called International African Expeditions; as Mr. Stanley puts it, he has been in a position to pay for every cubic inch of air he and his men have breathed, and every square foot of ground they trod upon. The object of the King of the Belgians appears to have been entirely disinterested—simply to do what he could to render accessible to commerce and civilization and thereby develop the resources of the great interior of Africa. For this purpose the Congo formed a splendid channel of communication, only, unfortunately, its lower course for many miles is obstructed by impassable cataracts. To sur mount this obstruction had been the object of Mr. Stanley's work. He states that already he has carried a well made road, fifteen yards wide on an average, from below the cataracts 230 miles along the north bank of the river, far beyond Stanley Pool, and therefore well into the navigable upper waters. To assist him in his undertaking he has not only had native workers, but relays of young Europeans as superintendents, and for this work he finds Englishmen better than any others, and would be glad to have a fresh supply to send out. So substantially has this road been constructed, that it has stood the deluges of rain that break down upon it from the mountain sides, and has borne the heavy traffic which the transport of engineering plant to the upper reaches has rendered necessary. Causeways have been laid where necessary and bridges built, and the road has, by means of excavations, embankments of stone, and layers of earth been carried right around the face of a mountain which comes sheer down to the river at one place. On rounding the mountain, Mr. Stanley states that the road enters an avenue of exquisite beauty and coolness, which has been cleared through the forest. So thickly timbered is the country in some parts that thousands of trees have had to be felled and their roots grubbed up or leveled. At intervals along the road, stations have been planted, and already there is a regular service of couriers between the stations, and by them a growing trade is being established. As to what are the possibilities of commerce along this route, he states that during the progress of the work, a million yards of Manchester goods have been distributed through the country in payment for labor and other services performed by the natives. One of the articles of transport along the new road was a fine steam launch, with which Mr. Stanley has done some good exploring work, some 400 miles above Stanley Pool, quite 700 miles above the mouth of the river. The launch, for example, was taken up a new river, opening from the south bank of the Congo some distance above Stanley Pool, and which, it was found, led into a fine lake. The lake was covered with fishermen's canoes, whose occupants looked aghast at the snorting monster puffing out smoke, and fled in dismay. One, however, was caught, and after being soothed down and kindly treated, was sent off loaded with presents to his wondering fellows peering from among the bushes on the shore.

In Mr. Stanley's opinion, the soil is capable of unlimited development for crops of all kinds, and by judicious use, the supply of caoutchouc in the forests is inexhaustible. The greatest difficulty to the utilization of the river throughout its navigable length is the almost untamable cannibal tribes who inhabit the upper reaches between Stanley's furthest point and the neighborhood of Nyanginé. It is hardly to be supposed, however, that these cannibal tribes will be allowed to block the onward march of civilization, trade, and commerce for any lengthened period. The aboriginal savages of all the other continents have had to give way to the progress of these progressive powers, and those of Africa will not form an exception, when the desirability of the country has been established.

ARTIFICIAL MOTHERS' MILK.

OTTO LAHRMANN of Altona has contrived the following process for converting cow's milk into a very fair imitation of human milk. The milk used is analyzed and a suitable quantity of (milk?) sugar added; either water or cream is added according as the milk is too rich or too poor. As cow's milk contains more indigestible albuminoids than mother's milk, Lahrmann adds a suitable ferment, (*e. g.* pancreas ferment) to convert the excess of albuminoids (that are coagulated by acids) into peptones, or peptonoid substances. The method was patented in Germany in December, 1881.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

TABLE OF CONTENTS.